TOPICS OF THE MONTH

A question of know-how

WILL chemical plants of the future be designed and built by integrated groups of plant manufacturers or contractors, on the lines of the ' consortia ' which are responsible for atomic energy projects? This is the interesting possibility that springs to mind in considering the remarks of Sir Walter Worboys at the annual dinner of the British Chemical Plant Manufacturers Association (reported more fully on page 386). Sir Walter, as chief guest, was replying to a speech by Mr. H. W. Fender, B.C.P.M.A. chairman, who called for greater co-operation between the chemical industry and chemical plant manufacturers, and appealed for more ' know how ' to be made available to the plant makers, particularly as this would be of great help to exporters of chemical plant.

Sir Walter's answer was to challenge whether the existing structure of the chemical engineering industry was ideally suited to the competitive conditions of the future. He felt that fewer and bigger plant manufacturing firms might enable British chemical plant manufacturers to do more research and development work and, together with increased co-operation between the chemical industry and the plant manufacturers, would result in economy in the use of technical personnel. Better plants would be available because, whereas in general the engineering department of a chemical manufacturer would only build one or two plants of a given type, a chemical plant manufacturer might build several. Their ' Mark V,' for example, ought to be a better plant than ' Mark II.'

Sir Walter pointed out the fallacy of thinking of the chemical plant industry as a homogeneous whole; some distinction had to be made between contractors for complete plants and suppliers of individual items of equipment. In very many cases in the past, the chemical manufacturer has found it easier to ensure the right sort of collaboration in designing and building a plant if all the plant design, procurement and construction is done within his own organisation. If the chemical plant manufacturer is to be given responsibility for design procurement and construction, then he and his staff must be of the same calibre and must command the same skills as does the chemical manufacturer's own engineering department.

This last observation of Sir Walter Worboys must sound strange to some ears, for the chemical engineer is obviously the key man in any chemical plant design and construction organisation, and there must be more chemical engineers engaged in chemical plant manufacture than in any other industry. So it all comes back to a question of reorganisation and any successful reorganisation must start with improved co-operation between the chemical and allied industries and the plant manufacturers who serve their needs. This need for greater co-operation has been stressed before in these columns and it is gratifying to find that in this broad aim both the B.C.P.M.A. and the Association of British Chemical Manufacturers are united.

Chemical expansion in Israel

WE constantly receive reports of ambitious plans for industrial development, not only from the U.S.S.R., China, Hungary and other countries of the same sphere, but also from India and similar underdeveloped countries where, apparently, the task of increasing, say, iron and steel production, or chemical output by two or three times is contemplated without batting an eyelid. And, surprisingly, it can often be done; a fact which reflects the energy and tenacity of purpose of the inhabitants in striving towards the goal of complete industrialisation. Even bearing in mind the technical and economic assistance they receive from one source or another, and the easier task of doubling production in a country where production is not so very great to begin with, the industrial progress that is being made despite unfavourable geographic and climatic conditions is truly astonishing.

One of the most interesting of these countries is Israel, which has one of the fastest-growing chemical industries in the world. The latest plan for economic development, over the period 1960-65, aims at an average investment per worker in the chemical industry of I£50,000. Production will be more than doubled, from I£154 million at present to I£336 million in 1965. Chemical exports are expected to total I£126 million, with an additional investment of some I£227 million. Exporting close to 40% of the industry's output seems a very ambitious target, but, compared with Holland's 50% and Switzerland's 70%, it is thought to be by no means an impossible one.

Further evidence of the fast pace of Israel's industrial development comes in the annual report of Fertilizers & Chemicals Ltd., the country's largest industrial enterprise, whose considerable chemical and fertiliser operations are still expanding. Output in nearly all the company's plants exceeded that of the previous year by 10 to 50%, while production of several new chemicals was started. New products recently marketed for the first time include nitric acid, concentrated nitrogenous solution and sodium pyrophosphate. With the acquisition of all assets and liabilities of the Kadimah Chemical Corporation, whose plant occupies an adjacent site, the company entered the field of organic chemistry, taking over and expanding the production of detergents and organic by-products.

On the engineering side, Fertilizers & Chemicals' new dry-ice plant is due for completion in 1959, while plans for mixed granulated fertiliser and aluminium sulphate (from Negev clay) are on the drawing boards.

Rubber from turps

THE Germans succeeded in starting synthetic rubber manufacture on a commercial scale because they were driven on by the need, essential to the Nazi programme, to make their country independent in its supplies of essential materials. And so at last they launched the manufacture of *ersatz* caoutchouc using the indigenously plentiful raw material, butadiene.

It is carrying things a step further when you start looking round for a substitute raw material from which to produce synthetic rubber. This is what appears to be happening in Sweden, at the Royal Institute of Technology, where investigations are being centred on sulphate turpentine, a by-product of paper manufacture, as a base for synthetic ' natural ' rubber. Production of this type of rubber on the basis of sulphate turpentine is not expected to prove commercially remunerative, but it is believed that such a process would be of great importance in times of emergency.

Nuclear ' war ' in Canada . . .

STRONG feelings have been aroused about Canada's present atomic power development programme, which is concentrated mainly on natural-uranium-fuelled, heavy-water-moderated types of reactors. Mr. Winnett Boyd, president of the design and engineering firm which bears his name, seems to have started a small-scale ' nuclear war ' with a recent speech in which he threw doubts on the desirability of the uranium/heavy-water reactor from the practical economic point of view, and stressed the advantages of a high-temperature, gas-cooled, graphite-moderated system.

His remarks brought a stinging rejoinder from Mr. J. L. Gray, president of Atomic Energy of Canada Ltd., who said that his company's staff had given very serious consideration to the design mentioned by Mr. Boyd and had found it unsuitable in some respects. To develop a system of this sort in Canada to the point where a full-scale plant could be built would be a long and costly affair. Mr. Gray did not agree with Mr. Boyd's contention that graphite was a much better moderator from an engineering point of view and was plentiful, cheap and easily machined. He referred to a study carried out independently by Canadian and British engineers which showed that the final estimated cost of a graphite moderator ' in place ' under Canadian labour conditions is approximately the same as the equivalent moderator using heavy water.

Mr. Gray also countered Mr. Boyd's comments about the safety aspects of using pressure tubes. The Canadian NPD-2 and *Candu* reactors were being designed so that pressure tubes could be replaced in the event of failure. Numerous tests of actually rupturing tubes have indicated that bursting a tube under full operating conditions causes much less disturbance or damage than was originally estimated.

Considering a suggestion that Canada should co-operate with Britain in the construction and operation of a diffusion (uranium enrichment) plant, Mr. Gray pointed out that the question had been throughly investigated by both the British and the Canadians and to date the answer has been a categorical No. Recent evaluations by A.E.C.L. indicated that, if the construction of a diffusion plant of minimum size were started now, using power costs estimated for a site at Hamilton Falls, and the plant was operated to meet a demand, at U.S. published prices, of 50% of the world's requirement for enriched uranium for civil uses, the project would have a net loss of $50 million p.a. for ten years.

. . . and a plea for profit-motivation in U.S.A.

IN the U.S.A. there are more widespread misgivings about the way things are going in the atomic energy field, although this time the discord springs from frankly commercial considerations. The feelings of the discontented are expressed by Dr. C. Starr, general manager of the Atomics International Division of North American Aviation Inc., in an address before the Atomic Industrial Forum in Washington.

His main theme was that U.S. atomic development was being stifled because government domination in this field took the vigour out of private enterprise. The profit motive, as a stimulant, was being neglected. ' In its struggle to develop, industry has discovered that this domain of technology is pervaded with an unwritten, unspoken but nevertheless real policy to prevent the establishment of a preferred position in this field by any private company as a result of pioneering participation in the national programme.' Dr. Starr went on to say that this unenunciated policy existed in spite of the fact that there were, in the U.S.A., ample judicial agencies, controls and processes designed to prevent monopoly or the abuse of commercial privilege.

He enumerated what he thought were the causes of the present unsatisfactory position. First, in spite of the prophecies of doom concerning the availability of conventional fuels, the true customer for atomic power, the utility industry, had not yet been convinced that these predictions were valid. On this point, Dr. Starr urged that national planning should not be unduly influenced by short-term factors such as the immediate surplus of oil or coal.

The second curb to a sense of national urgency in this field was the lack of effective international competition, the Soviets lacking leadership in this field while the United Kingdom did not have a suitable product for foreign customers. A third handicap was the lack of sufficient technical accomplishment to provide a sound basis for commercialisation. Compared with the military programme, commercial atomic power developments had been conducted on a shoe string.

In addition to these general factors, the national laboratories—governmental research and development institutions set up primarily for military purposes but eventually covering all aspects of atomic energy—were now in direct competition with the atomic industry for government support.

Fluid-bed cooling

A PROMISING new method of cooling ingot moulds in the iron and steel industry, using chemical engineering principles, is that of the fluidised bed. In this method, the mould is introduced into a bed of fine, granular material which is fluidised by passing a current of air through it, the container being surrounded by a jacket of water.

In present iron-making practice, moulds are just left to cool off, which means that much time is wasted and the moulds are lying idle. Sometimes quenching with water is resorted to, but this is bound to weaken the mould, eventually causing it to crack.

Efforts to perfect the fluidised-bed method of cooling are 'getting warmer.' The British Iron and Steel Research Association, which has been carrying out laboratory experiments and searching for a fluidisable material with suitable properties, has got to the stage of carrying out pilot-plant tests with a fluidised bed capable of taking 10-cwt. moulds which has been set up in their Sheffield laboratories. It is hoped that these experiments will result in a rapid and uniform cooling which will not be so hard on the mould as water quenching.

In experiments, the mould, after stripping, is put in a fluidised bed which is surrounded by a water jacket. Thermocouples embedded in the walls of the mould make it possible to record the rate of cooling. Pilot-plant tests with a fluidised bed capable of taking 10-cwt. moulds are being carried out in the Sheffield laboratories of B.I.S.R.A.

This and other recent advances in iron and steel research were illustrated at the Battersea, London, laboratories of B.I.S.R.A. when it held its 'open days' at the end of October. The visitor to these laboratories cannot help being impressed by the vigorous attack that is being made on the practical problems of iron and steel production and utilisation. With all the clever ways that are being devised of introducing push-button methods of production and control it seems hard that the cooling of moulds, which on the face of it seems a relatively simple matter, should still present a problem.

New high-temperature material

A SEARCH for stator-blade materials for use in gas turbines at 1,200°C. has led to the production of a new composition, based on silicon nitride, which should make a useful addition to the present range of high-temperature ceramics. Its high thermal-shock resistance and chemical inertness suggest that silicon nitride may be of use as a support for high-temperature catalysts, as thermocouple sheaths, crucibles, supports for advanced heat treatment, and containers for special purification and diffusion operations like those used in the semi-conductor field.

The new ceramic was produced in Britain by the Metallurgy Division of the Admiralty Materials Laboratory. Composed of cheap, non-strategic materials, it can be formed to very close tolerances by conventional machining methods and has good mechanical strength at temperatures up to 1,200°C.

Fluidised-bed equipment has been used in tests on the thermal shock resistance of silicon nitride, wedge-shaped discs of the material being prepared as specimens. So far it has been shown that these specimens can be subjected to as many as 50 cycles of rapid heating to 1,000°C. and cooling before radial cracks begin to appear at the edges. These tests indicate that silicon nitride is outstanding among refractory materials in its resistance to thermal shock and under some conditions approaches the performance to be expected from metals.

Side door to the chemical profession?

A LARGE body of British chemists is worried about a problem which may be expressed by the formula:

$$HNC + ARIC \rightarrow FQCh$$

where *HNC* = Higher National Certificate in chemistry, *ARIC* = Associateship of the Royal Institute of Chemistry and *FQCh* stands for a fully qualified chemist.

It is felt that, firstly, the process involved is often slow and cumbersome and, secondly, the end product may not have the properties desirable in an industrial raw material. In fact, it is felt that the product is often too chemically pure and might be improved by the inclusion of, say, some swarf and grease from the engineering workshops. And so it is being suggested that some alternative formula should be evolved in which the *ARIC* is replaced by some other ingredient.

In more everyday terms, there is some anxiety about the present situation whereby a student, after getting his H.N.C. in chemistry, has to go on to take the examination for the A.R.I.C. if he wants to become a fully fledged member of the chemical profession. This would be all very well if many part-time students were not prevented by their personal circumstances from following this course. And, anyway, who wants to spend so much time studying pure chemistry if his job calls rather more for a knowledge of a particular industry or technology?

There seems to be a strong case for establishing some new qualification, involving an examination which students can take as an alternative to the A.R.I.C. Approaches have been made to the R.I.C. about this, but the Institute has not so far shown itself favourable to the idea.

If the Institute does not act, then why not set up some other body which will? The British Association of Chemists, which has been energetically pursuing this matter, recently called for the views of training colleges on a proposal to set up an Institute of Chemical Technology. The idea is that the new institute would establish two grades of membership—an associateship and a fellowship—based on the attainment of a certain technological standard following the H.N.C.

At a recent meeting at Crewe, called by the B.A.C.,

this proposal was chewed over by the representatives of 60 colleges which prepare students for the H.N.C. The majority were sceptical about a suggestion that some 80% of students getting the H.N.C. in chemistry were left 'high and dry,' but agreed that the situation was sufficiently untidy for something to be done about it. Failing suitable action by the R.I.C., there were certainly strong arguments in favour of a new institute, which would offer part-time students a course that is broad rather than deep, equivalent to the Dip. Tech. for day students.

Will the R.I.C. relent? At any rate, something is bound to come of it all, for the result of the meeting was the formation of a steering committee consisting of 12 people from technical colleges and six from industry, while the R.I.C. is being asked to nominate a representative or representatives.

Ultra-sensitive level gauge

A RECENTLY developed device called a 'hunting-probe liquid-level indicator' can be used to measure changes in liquid levels with very high accuracy—amounting in one particular application to below $\frac{1}{10}$ mm. over a range of 10 m.

Who wants a level indicator all that accurate? Well, the United Kingdom Atomic Energy Authority hold the patent rights and it seems the new device could be used to provide very fine control in water-moderated reactors where the height of the water in the core is the factor determining the power level.

Major components in one application are a spring-loaded contact plate positioned at the datum point, the electrical probe with a platinum point contact suspended from a stainless-steel wire wound on a drum of similar material, a split-field d.c. motor, a thyratron and a level indicator. To start operations, with the probe out of the liquid, a changeover switch is actuated which energises the first field of the motor and turns the drum, allowing the probe to descend. As soon as the point of the probe touches the surface of the liquid, a circuit is completed which fires a thyratron. This energises the second field of the motor with twice the current in the first field, overriding it and turning the motor in the opposite direction. The probe then rises until contact is broken with the surface of the liquid, when the first sequence is repeated.

Thus the probe 'hunts' above and below the surface of the liquid, but the circuit responds so fast that the movement of the probe is only a few thousandths of an inch. The probe's mean position gives the true level. The hunting motion can be taken up so as not to be repeated by the pointer, the latter always indicating the mean position. The pointer on the level indicator is arranged to rotate only once for a very small change of level and the number of turns is given on a second dial.

The gauge is virtually independent of the nature of most liquids. It is so sensitive that it can be used with demineralised water, not normally considered as a conductor.

Fertiliser from chimney stacks

NUMEROUS ways of removing sulphur from flue gases have been investigated and attempts have been made to make economical use of the sulphur by further processing, but nothing so far has seemed so immediately attractive as the new process being offered by Chemical Construction (G.B.) Ltd. This appears to offer a cheaper method of producing ammonium sulphate and the company feel that it could have a considerable impact on the present situation in which ammonium sulphate is losing ground to other, more economically produced, nitrogenous fertilisers because of its high raw-material costs.

In the *Chemico* process, ammonia gas is introduced into the flue gases between the economiser and the air heater. The gas temperature is not lowered and wet scrubbing is not used, so the condition favourable for causing 'stack droop' is not created. The ammonia reacts in the gaseous phase with the sulphur oxides produced by combustion of the sulphur contained in the fuel. The product is a fog of ammonium sulphur salts such as sulphite, bisulphite, sulphate, thio-sulphate, etc. These solid salts are quantitatively removed as a powder from the gas stream in the high-voltage electrostatic precipitators installed at most urban power stations.

The residue extracted by this process is a mixture of ammonium sulphur salts and fly ash and, when separated from the fly ash, the salts form the basis for the production of ammonium sulphate fertiliser.

New industries in Ireland

IT'S 'as you were' for the time being with the project for a new nitrogenous fertiliser factory in Ireland. After considering the report of the committee set up by the Minister for Industry and Commerce, the Government has decided that the project could not be justified at the moment when there has been a recent fall in the prices of imported nitrogenous fertilisers.

Meanwhile, it's 'full steam ahead' with phosphate fertilisers down in County Wicklow, where a new £200,000 superphosphate plant has been opened for Shamrock Fertilisers Ltd. The production potential is 70,000 tons p.a. Total Irish import of super-phosphates last year was more than 50,000 tons.

But all other industrial developments in Ireland pale into insignificance alongside the new £12-million, 2-million-tons-p.a. petroleum refinery at Whitegate, County Cork. The design is based on a crude distillation capacity of 39,600 bbl./day of Middle East crude and the processing units include an atmospheric crude topping unit, a catalytic reformer for octane upgrading of virgin naphtha, a copper sweetening unit and a middle distillate catalytic desulphurisation unit. Notable features of the refinery are the extensive use of air-cooled heat exchangers and the maximum use of reinforced-concrete construction rather than structural steel. A full description of the refinery appears in the November issue of our associate journal, *Petroleum*. We also show some pictures on page 405.

Particle Size Analysis for the Chemical Engineer

By L. Cohen, Ph.D., D.I.C., F.Inst.P.
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For the chemical engineer who is interested in using particle size analysis for routine process control or to obtain design data, this article summarises briefly the applications of particle size distribution, the various types of instruments available, and the factors involved in the choice of an instrument.

THE advantages of using finely ground material are becoming recognised in many branches of chemical industry, particularly since the development of new methods of fine grinding, such as the fluid energy mill. As a result there has arisen a need, perhaps not yet fully recognised, for methods of measuring the particle size distribution of powders, particularly in the sub-sieve range (say, less than 50 microns).

This article describes some currently available methods. Although some comments are made on the limitations of the various instruments, this is not intended as a critical review but as a brief guide for the uninitiated to this rather controversial field.

Particle size distribution in industrial processes

The properties of powders which are affected by the particle size distribution include the following:

(*a*) *Surface area per unit weight.* This increases as particle size decreases. The rates of most chemical reactions and many physical processes, such as gas adsorption and liquid solubility, are highly dependent on this property.

(*b*) *Packing density or voidage.* This depends in a complex manner on the distribution of sizes rather than on their absolute values. Resistance to passage of fluid through a bed and the strength of a sinter are two properties which depend on the packing density.

(*c*) *Colour and reflectance.* These become particularly important as the particle size falls below 1 or 2 microns. The covering power of paints, for example, is very dependent on size distribution.

(*d*) *Stability and flow properties of liquid suspensions.* The absolute size largely controls the stability of a suspension, *i.e.* the rate at which the suspension is destroyed by the solid particles falling out. The size distribution, however, has a considerable effect on the rheological properties, which are important in such processes as the hydraulic conveying of solids and the dense-medium cleaning of coal.

(*e*) *Rate of settling of airborne suspensions.* This is a function of the absolute value of the particle size and is an important factor in the design of gas cleaning equipment such as cyclones and electro-precipitators.

Effect of particle size and shape

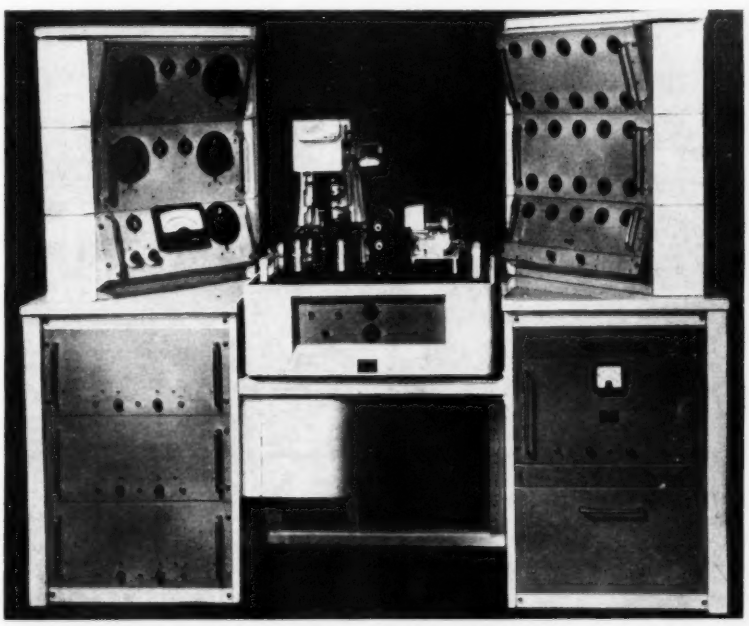
For sizes down to about 50 microns, sieves or screens are used almost exclusively to separate the powder into size fractions from which the distribution can be derived.

In the sub-sieve range a variety of methods have been used based on various properties of powders. The method of analysis used for any one powder should, ideally, depend on the purpose for which the information is required, *e.g.* if the settling properties are of interest, as in gas cleaning equipment, then the analysis should be carried out by a sedimentation method. It does not always prove possible to follow this advice, but care must be taken in interpreting one property of a powder in terms of another, particularly if the shape of the particles is very different from spherical (*e.g.* needle- or plate-like).

With perfectly smooth, spherical particles, which normally occur only when the powder is formed by condensation or solidification, the methods are theoretically equivalent. The results tend to diverge with increasing departure from sphericity.

Optical methods of size analysis

Perhaps the most commonly used method, and apparently the most direct, is the optical microscope. One



Five-channel particle counter and sizer by Casella (Electronics) Ltd.

disadvantage is the tedium of having to measure a large number of particles so as to obtain a representative sample. This can be partially ameliorated by the use of special graticules, such as that designed by Fairs, combined with a manually operated counter such as that marketed by Cooke, Troughton & Simms Ltd. Alternatively, the whole process can be mechanised by using an electronic scanner. Automatic measuring devices based on this principle are marketed by Mullard Ltd., Cinema-Television Ltd., and Casella (Electronics) Ltd.

Special features of microscopic methods

The chief disadvantage of the microscope is that it should be limited to spherical or nearly spherical particles. Misleading results can be obtained with non-spherical particles, particularly in the dimension perpendicular to the microscope slide.

The microscope is particularly useful for rapid, semi-quantitative assessments.

Other optical properties of more limited application are the colour and reflectance of dry powder and the turbidity and light scattering of suspensions in liquids.

Permeability

The permeability of a bed of powder, packed with a known voidage, is a function of the particle size distribution. The permeability is calculated from the drop in pressure across the bed when a fluid is flowing through it at a known rate. Instruments based on this method are made by the Fisher Scientific Co., U.S.A. (marketed in Britain by Kek Ltd.) and by Griffin & George Ltd. This method really measures the surface area of the powder and the assumptions made in transforming this into a particle size distribution are a source of error.

Electrostatic method

If airborne dust is passed through a corona discharge the particles pick up a charge the magnitude of which is proportional to its surface area. If the total charge of a known weight of the dust is measured by collecting the dust in an electrometer the surface area per unit weight, and hence the particle size distribution, can be calculated. The British Thomson-Houston Co. Ltd. have demonstrated a prototype of this device. This again is essentially a measure of surface area and also makes assumption as to the way the individual particles pick up charges.

Centrifugal sedimentometer made by A. Gallenkamp & Co. Ltd.

Elutriator by Griffin & George Ltd.

Elutriation

The principle on which both elutriation and sedimentation are based is that the terminal velocity of a particle falling freely in a fluid is a function of the particle size. For Reynolds numbers (based on the particle diameter) less than 0.4 the terminal velocity varies as the square of the particle diameter (Stokes' law). For Reynolds numbers greater than 500 the variation is as the square root of the particle diameter and at intermediate values, as the first power of the diameter less a constant.

In an elutriator the particles are dispersed in a vertical tube carrying a stream of fluid moving upwards at a known velocity; particles with a terminal velocity greater than the fluid velocity fall to the bottom of the tube while the remaining particles are carried forward by the stream. By using a number of tubes in series a separation of the powder into size ranges is effected.

The principal defects of elutriators are: (*a*) the lack of sharpness of the cut-point, *i.e.* a considerable number of the particles in a given nominal size range are, in fact, outside that range; (*b*) it is difficult to predict the true size range of any cut; and (*c*) each cut covers a fairly wide range of sizes and so the size distribution can only be given very crudely. It is probable that these defects are largely due to the complex flow conditions in the elutriator tubes which is a result, in part, of trying to make the apparatus a manageable size.

Elutriators may be found useful for comparative tests under closely controlled conditions. Laboratory elutriators of various designs are manufactured by A. Gallenkamp & Co. Ltd., Griffin & George, International Combustion Products Ltd., and Sharples Centrifuges Ltd.

Centrifugal elutriation

The elutriation process can be considerably speeded up, particularly for small-sized particles, by applying a centrifugal action. An improvement in accuracy is also obtained since the gas flow is quite strictly controlled.

In the centrifugal elutriator the dust is fed on to a rotating disc where it is subject to a centrifugal force and an opposing flow of air. Depending on its size the particle is either carried off by the gas stream or is thrown to the walls, exactly analogous to a gravitational elutriator.

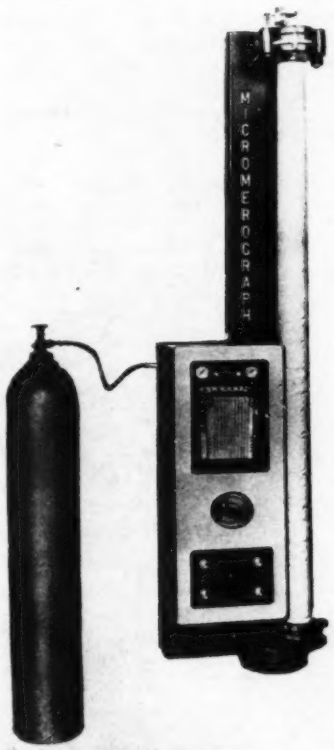
The *Bahco*, marketed by the French firm, Etablissements NEU, is an instrument of this type.

Sedimentation

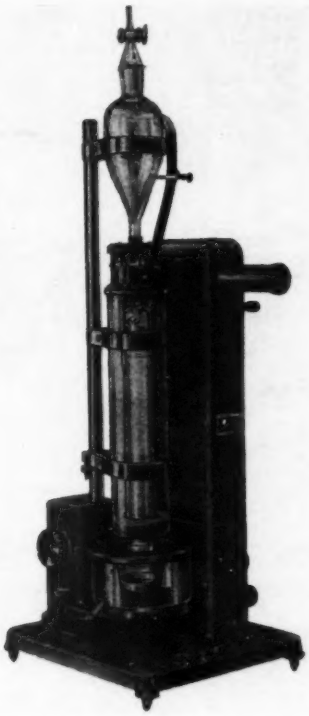
The main advantage of sedimentation over elutriation, which is basically equivalent, is that in the former it is possible to maintain the Reynolds number in the region where Stokes' law applies, thus increasing the simplicity of the process and its accuracy.

A commercially available instrument which uses sedimentation through a gas is the *Micromerograph*, made by Sharples Centrifuges. The dust sample is dispersed by a jet of gas at the top of a long column and the particles fall down the column on to the pan of a recording balance. The size distribution is calculated from the weight-time curve by a direct application of Stokes' law. The main disadvantage is the inability to disperse certain materials by the gas jet.

With liquid sedimentation the powder is usually uniformly dispersed throughout the column and a slightly more complex mathematical analysis is necessary to interpret the results than when all the sample is introduced at one level. A variety of methods is used to follow the sedimentation, the three which have been used in commercial equipment being: (*a*) measurement of the weight of material accumulating on a balance pan at the bottom of the column (sedimentation balance); (*b*) measurement of the change of concentration with time in a given layer by extraction of samples (Andreasen pipette); and (*c*) measurement of the change of concentration with time in a given layer by light extinction (photo-sedimentometers).



The 'Micromerograph,' offered by Sharples Centrifuges Ltd., employs the method of sedimentation through a gas.



Sedimentation balance (A. Gallenkamp & Co. Ltd.).

A sedimentation balance made by Gallenkamp uses visual observations of the deflection of a torsion balance; another, made by the German firm of Sartorius and distributed by Hudes Merchandising Corporation Ltd., gives a paper record of the increase of weight with time. From the rate of change of weight with time and Stokes' law the size distribution may be calculated. A careful dispersion technique must be used, as with all liquid sedimentation methods, in the preparation of the suspension. This may involve a considerable search for the appropriate dispersing agent.

The Andreasen pipette is used to extract a small, fixed volume of the suspension from a fixed depth at given intervals of time after the start of sedimentation. The samples are dried and weighed to obtain the change of concentration with time of the suspension at the specified depth. From this data and Stokes' law the size distribution is calculated. The disadvantages of this device are the rather high concentration of solid necessary to obtain a satisfactory sample, which may cause inter-particle interference, and the disturbance caused in the suspension by taking the samples.

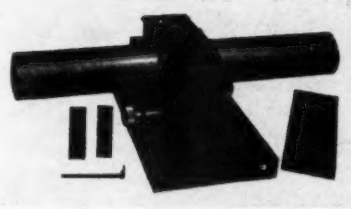


Photo-extinction sedimentometer (Evans Electroselenium Ltd.).

The photo-sedimentometer measures the change in concentration, during sedimentation, at one or more fixed depths in the suspension by the change in the intensity of a light beam transmitted by the suspension. By applying the Lambert-Beer law, which governs the ratio of the incident and transmitted light intensities, and Stokes' law the particle size distribution can, in principle, be calculated. A complication does arise, however, because the extinction depends on the particle size as well as the concentration and successive approximation must be used, particularly for the smaller sizes. Three instruments using this principle, but differing in design, are available. They are manufactured by Evans Electroselenium Ltd., Griffin & George, and Bound Brook Bearings (G.B.) Ltd., respectively. This method, again, measures the surface area of the solid in the suspension.

Centrifugal sedimentation

The methods described above are not generally applicable to particle sizes less than 2 or 3 microns. On the other hand, the electron microscope is most useful for sizes less than about 0.1 micron. In the intermediate size range the most promising method is that of centrifugal sedimentation in which the gravitational force used in ordinary sedimentation is replaced by a greater centrifugal force. This larger force is necessary to ensure that the sedimentation process for the smaller particles is complete in a time short enough to prevent external factors (*e.g.* convection currents) from interfering.

An instrument designed on this principle is made by Gallenkamp. It appears to have some limitations as to the kind of powder which can be analysed.

Choice of instrument

Several factors must be taken into account in the choice of instrument:

(*a*) Nature of the information required, *e.g.* full size analysis or percentage within a given size range.
(*b*) Purpose to which the information will be put. This has been discussed above.
(*c*) Speed with which results are required. If used for plant control purposes obviously the results are needed rapidly.
(*d*) Type of personnel available for carrying out the tests.
(*e*) Accuracy of the equipment relative to the requirements.
(*f*) Cost of the equipment.

These factors are, of course, interrelated. For example, an instrument with a high initial cost may be much cheaper in manpower, so that the cost of a single test averaged over a period may be lower than an instrument with low prime cost. Again, an instrument such as the sedimentation balance is capable of giving the full size analysis quite accurately, taking perhaps 4 hr., and is also capable of giving a less detailed analysis, less accurately, in a much shorter time.

Some instruments may be rejected because of their innate inaccuracy, particularly the elutriator. Others have special limitations; the gas jet in the *Micromerograph*, for example, is not always effective in dispersing the powder. Furthermore, the different designs of equipment based on the same principle often differ in performance.

The prices of the instruments range from £5 for the Andreasen pipette (drying ovens and balance are assumed to be available) through £50 for elutriators and the permeability apparatus, £100 for the photo-sedimentometer, £200 for the manual sedimentation balance and £600 for the recording version, £800 for the *Bahco*, to £2,000 for the *Micromerograph* and the electronic microscope scanner. These prices merely indicate the order of magnitude and should not be taken as exact.

Conclusions

The choice of an instrument for size analysis is very wide and it is not possible to pick out any one instrument as being the best in all respects and in all circumstances. The choice of an instrument must be made in the light of all the factors involved. Other instruments are being developed, but the overall picture is not likely to be changed in the near future.

Chemical Projects as 'Combined Operations'

'CO-OPERATION' PLEA AT B.C.P.M.A. DINNER

Closer partnership between chemical plant manufacturers and the chemical industry was urged by Mr. H. W. Fender, chairman of the British Chemical Plant Manufacturers' Association, at their annual dinner in London on October 28. Well over 800 members and guests, at least 100 more than ever before, attended the dinner, including guests from France, Russia, the U.S.A., Mexico and Japan.

Mr. Fender regretted that the chemical industry seldom used the plant industry as main contractors and pointed out that the industry now had available the technical facilities to do much more than supply individual items of plant. By bringing in the plant manufacturer at the inception of new projects, said Mr. Fender, customers could accelerate the completion of projects and have plants on stream more quickly than otherwise. Closer partnership was especially important in selling processes overseas. The British chemical plant manufacturer was being prevented from tackling a number of projects, particularly for Russia, because he lacked the know-how. Collaboration between the two industries could overcome this and ensure that, when British know-how was sold to foreign customers, British plant would be sold at the same time.

These points were taken up by the principal guest, Sir Walter Worboys, who has just retired from the position of commercial director of I.C.I. after 34 years' service with the company. In his view only 10% of the B.C.P.M.A. membership of 245 firms were chemical plant manufacturers in the sense that they could offer complete plants. The others were plant equipment manufacturers. ' In saying this,' said Sir Walter, ' I do not wish to belittle the rest of your members, because the effectiveness of a plant is determined by the effectiveness of individual items of equipment.' He thought that the industry could realise the ambitions outlined by Mr. Fender if there were fewer and bigger firms able to do the necessary research and development work. He conceded, however, that it was not only plant manufacturers who had to make new efforts. ' The chemical manufacturer must also make an effort; in particular he must try to overcome the habits of secrecy that have become deeply ingrained. Some information must be kept secret, but in my opinion there is a mass of information and experience which is really non-confidential and which would benefit our industries as a whole if it could be made generally available.'

But, however successfully a partnership could be developed, in Sir Walter's view chemical manufacturers could not afford to disband their engineering and design departments. ' It is the chemical manufacturer who decides whether or not to invest in plant for the manufacture of a new chemical and in making his decision he will want expert engineering advice.' Such advice would have to come from his own engineers, particularly in the case of new production where it was vital to observe secrecy.

However, there was no doubt that the two industries were interdependent and Sir Walter endorsed Mr. Fender's opinion of the advantages that could flow from closer partnership, particularly when selling processes and plants abroad. A stronger chemical plant industry could be the repository of a vast amount of plant operating experience which would be invaluable if made generally available. It was the chemical industry's duty to shed its obsession with secrecy and the plant manufacturer's duty to keep in close touch with his customers and ensure, for instance, that he gave them good after-sales service.

To Authors of Technical Articles and Books

The Editor welcomes practical articles and notes on chemical engineering and related subjects with a view to publication. A preliminary synopsis outlining the subject should be sent to The Editor, CHEMICAL & PROCESS ENGINEERING, Leonard Hill House, Eden Street, London, N.W.1.

In addition, the Publishers and Editors of the Leonard Hill Technical Group are always ready to consider technical and scientific manuscripts with a view to publication. Correspondence should be addressed in the first instance to the Book Production Manager, at the above address.

An International Atomic Reactor

THE world's first boiling-heavy-water reactor, and the first technological experiment of its kind to be run by an international board of management which jointly supplies the funds required, was officially opened at Halden, Norway, recently. The Halden reactor, which went critical three years and three months after the project was officially approved, is one of the three European undertakings in the field of nuclear energy organised by the O.E.E.C. European Nuclear Energy Agency.* It was built by the Norwegian Institutt for Atomenergi who, as the owners, will operate the reactor while a three-year programme of research and development is carried out under the auspices of the E.N.E.A. The main objectives are to obtain practical experience in the design, construction and operation of boiling-heavy-water reactors, and to investigate the economic possibilities of this type of reactor for power production.

The ultimate design specification of the reactor is 20 Mw. of heat produced in the primary circuit at a steam temperature of 230°C., corresponding approximately to 30 kg./sq.cm. pressure. It is intended to approach this specification in two stages, using different reactor cores for each stage.

The fuel charge for the first core consists of 7 tons of natural uranium, in the form of 1-in.-diam. rods canned in aluminium. The fuel was manufactured by the United Kingdom Atomic Energy Authority. In addition, enriched uranium oxide 'spikes,' clad in stainless steel, will be used to increase the reactivity. The fuel charge is assembled in the reactor core in the form of a hexagonal lattice.

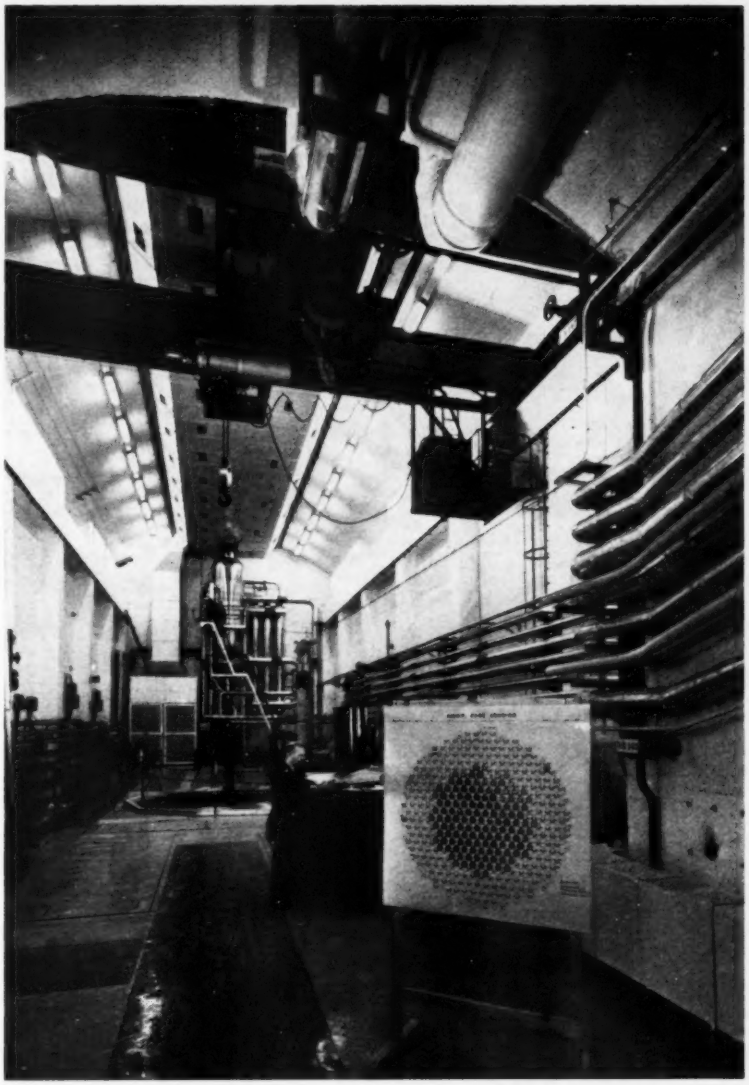
The fuel charge for the second core will consist of 1.5% enriched uranium oxide in *Zircalloy* cladding, and this will be substituted for the first core as soon as sufficient low-power experiments have been completed.

The core is contained in a mild-steel pressure vessel lined with stainless steel. Penetrating into the core from above are 19 cadmium safety rods. The rods are inside the pressure system and are fitted in pressure thimbles flanged to the top lid.

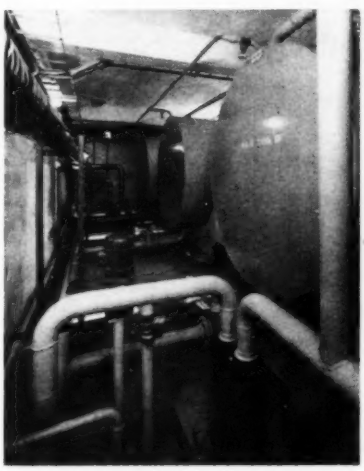
Sixteen tons of heavy water act as both moderator and coolant. Shrouds around the fuel rods confine the boiling to the annulus between the shroud and the fuel rod, and improve the general flow pattern in the core.

The reactor has been built in a cave blasted out of a rock. A tunnel about 60 m. long leads in to the main hall. The control room is placed in a building outside the rock, and normally no people work in the main reactor hall during the operation of the reactor.

*The other two are the European Company for the Chemical Treatment of Irradiated Fuels and the *Dragon* reactor project at Winfrith Heath, Dorset.



Reactor hall, seen from the tunnel. Board in foreground shows core loading.



Delay tanks for waste water.

Prepared Atmospheres in the Chemical Industry

By A. H. Holden, B.Sc., M.Inst.F.
(*Gibbons Applied Atmospheres Ltd.*)

This article discusses the production of purging, blanketing and process gases using standard or special generating units, with town gas, liquefied petroleum gases, etc., as the raw material. Various uses of these gases in the chemical industry are mentioned.

THE preparation and use of gases have been associated with the chemical industry since its beginnings, the prepared gas being used as a process gas, but it is only comparatively recently that the term 'atmosphere' has been applied to some of these product gases.

Prepared atmospheres have been generally used in the metallurgical and engineering industries for many years as a means of preventing scaling and decarburisation, and latterly as a means of increasing the carbon concentration in the surface layer. The chemical industry is now appreciating many of the advantages that close control of the atmosphere in reaction vessels can offer and it is not surprising that the use of prepared atmospheres is steadily increasing.

A 'controlled atmosphere,' as the term is understood in industry today, may be defined as a gas or mixture of gases used in a particular process to prevent some undesirable effect that may otherwise occur, or to bring about a desired effect by the action of one or more of the components of the atmosphere.

Applications of prepared atmospheres

The gas and petroleum industries have for a long time used specially prepared gases as purges for storage vessels, gas holders and pipelines, etc., to prevent the entry of air to form explosive mixtures with inflammable gases and vapours during filling, emptying and commissioning operations. This, and the similar one of reducing fire risk in hazardous situations, is probably the main use of atmosphere preparation plant in the chemical industry today.

The range of applications has extended considerably in recent years and is still expanding. Standard generators now available range from the relatively simple type used to supply purge gases, where the permissible concentration of oxygen and/or combustibles is not critical, to the elaborate preparation units required to produce gas of a purity comparable to that associated with cylinder gases.

A summary of the accepted applications of protective atmospheres is given in Table 1 and it will be seen that the prevention of oxidation is now one of the most important.

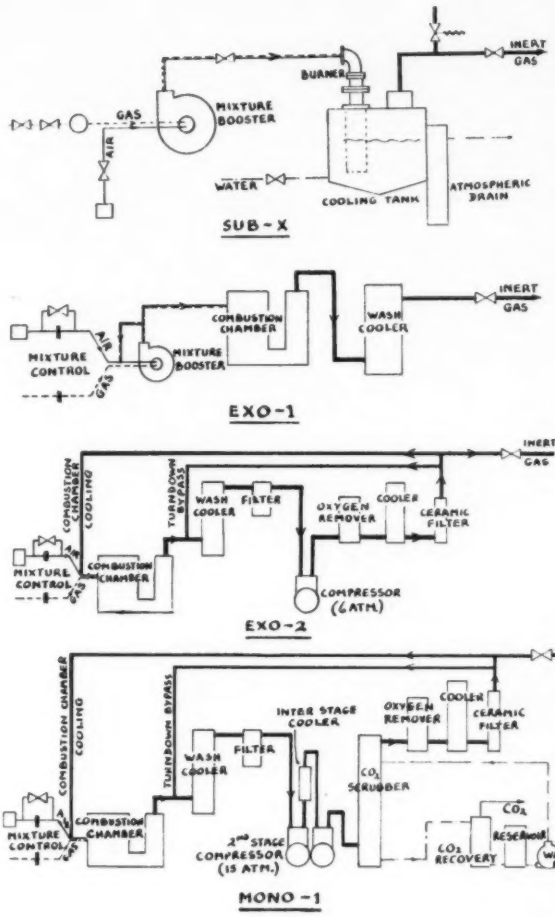
Basic fuels

The usual sources of most protective atmospheres used in industry, when these are derived from generators, are the gaseous or liquid fuels which are readily available. Town gas is very commonly used as are the liquefied petroleum gases propane and butane—the latter being particularly useful in applications where sulphur cannot be tolerated. Town gas is subject to changes in composition and specific gravity which make very precise control of the composition of the atmosphere resulting from its combustion somewhat difficult, but for most ordinary applications these changes are of small importance.

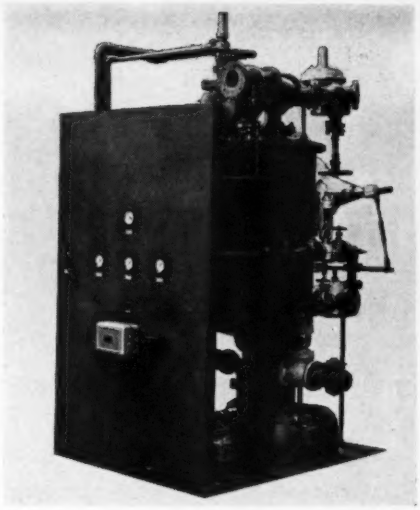
Distillate fuel oils are less frequently used, largely because of their higher sulphur content and, until comparatively recently, the difficulty of ensuring complete combustion without either excess air or unburnt combustibles. These difficulties do not now apply and generators are available today burning diesel oil and producing gases free from undesirable constituents.

Table 1. Applications of Inert Gas in the Chemical and Related Industries

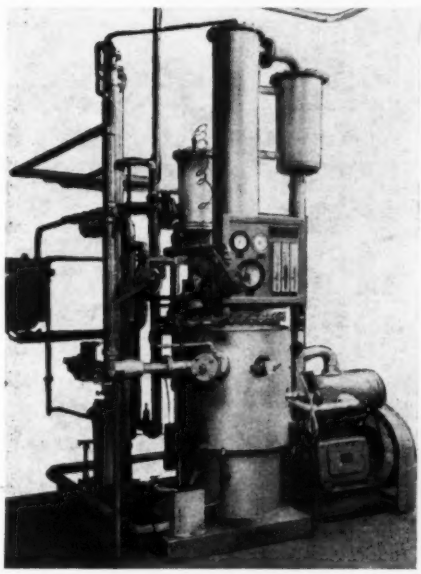
Process	*Serving as*	*Prevention of*
Welding of ducts and fuel containers	Purging gas	Explosion, fire
Exchanging distributor bottoms in bubble towers	Purging gas	,, ,,
Grinding explosive materials	Purging and transportation gas	,, ,,
Closing refining plants	Purging and blanket gas	Explosion, fire and corrosion
Emptying containers holding rubber	Pressure gas	Explosion
Forming inner tyre tubes, rubber boots, etc.	Pressure gas	Oxidation
Starting gas plants, filling gas storage plants	Purging gas	Explosion
Transporting heavy oils, paint and varnish in pipelines	Pressure gas to exclude air	Oxidation which leads to formation of layers in pipes
Manufacture and storage of paint and varnish	Blanket gas	Oxidation
Emptying tank wagons containing explosives	Pressure gas	Explosion
Spinning synthetic fibre	Blanket and pressure gas	Oxidation
Manufacture of celluloid	Blanket and pressure gas, fire-extinguishing gas	Explosion
Manufacture of synthetic resin	Blanket and transportation gas	Oxidation
Recovery of carbon disulphide	Blanket and transportation gas	Explosion
Gas-adsorption drying plants	Purge gas	Explosion
Storage of grain	Blanket gas	Killing parasites; maturing of unripe fruit



Simplified flow diagrams for four types of gas generators.



An atmosphere preparation unit of the 'Sub-X' type, giving 15,000 cu. ft./hr.



An 'Exo-II' generator of 2,000 cu.ft./hr. capacity.

Types of generators

Basically nearly all the atmosphere preparation units in use today consist of metering devices by which the fuel and air are measured and mixed before entering the combustion or reaction chamber, which in turn is followed by cooling and often purification. A blower or compressor is usually used either to handle the air or fuel/air mixture before combustion and/or the cooled products, afterwards enabling the prepared gas to be delivered to the point of use at the necessary pressure.

If combustion is approximately complete the product gas will consist of a mixture of nitrogen, carbon dioxide and water vapour with very small percentages of possibly oxygen or unburnt combustibles. Atmospheres of this type are used as blanket gases and purges in explosive situations and are built with very large outputs for the petroleum industry.

The *Sub-X* unit which is built by agreement with Thermal Research & Engineering Co. Ltd., U.S.A., is of this type but is unusual in that the combustion chamber is a water tank into which the products of combustion are discharged below the surface. Intimate mixing with the water results in very rapid cooling and the removal of practically all the water-soluble impurities normally present. Standard sizes are available up to 60,000 cu.ft./hr. gas- or oil-fired and the equipment includes all normal safety controls.

The atmospheres produced by the generators so far described contain carbon dioxide and water vapour—the amount of water vapour depending on the temperature of the gas leaving the cooler, which again depends on the cooling-water temperature.

The water vapour content can be reduced by compression before cooling, the dewpoint then being a function of the pressure. This is the principle of the *Exo-II* and *Exo-III* generators, the only difference being in the number of stages used in compression. The *Exo-II* produces a gas of –6 to –8°C. dewpoint, while the *Exo-III* with two-stage compression produces –15 to –18°C.

Table 2. Types of Inert* Gas

Type		Specification in accordance with VDL operation	Gas composition, volume%						Dewpoint, °C.
			H_2	CO	CO_2	CH_4	N_2	O_2	
(a) Bottled gases	Argon	——	0.001	—	—	—	0.098	0.001	−50
			(Argon 99.9%)						
	Helium	——	0.01	—	—	—	—	—	−50
			(Helium 99.9%)						
	Hydrogen	Hydrogen impure	99.8	—	—	—	—	0.2	−30
		Hydrogen pure	100.0	—	—	—	—	—	−50
	Nitrogen	Nitrogen impure	—	—	—	—	99.8	0.2	−30
		Nitrogen pure	1.0	—	—	—	99.0	—	−50
		H_2N_2 gas mixture	30—10	—	—	—	70—90	—	−50
	Carbon dioxide	——	—	—	99.8	—	0.2	Traces	−30
(b) Cracked gases	Cracked ammonia	Ammonia cracked gas	75	—	—	—	25	—	−35
	Cracked methanol	Methanol cracked gas	65	31	2	2	—	—	−35
(c) Partially combusted fuel gases	Exothermic	Exogas I	25—0.5	14—0.5	3—10	1—0	57—89	0.01	+20
		Exogas II							−8
		Exogas III							−18 to −50
	Exothermic CO_2 removed	Monogas I	25—0.5	14—0.5	0—1	1—0	60—98	0.01	−18 to −50
	Exothermic CO_2 removed and CO converted	Monogas II	25—0.5	2—0.5	0—1	1—0	72—98	0.01	−18 to −50
	Exothermic with complete removal of CO_2 and CO	Monogas III	25—0.5	Traces		1—0	74—99.5	0.001	−50
	Endothermic	Endogas	50—32	20—18	0—1	2—0	28—48	0.01	−25 to +20

* The word ' inert ' is used here in the sense in which it is usually used in the petroleum and gas industries, *i.e.* meaning a gas consisting essentially of nitrogen and carbon dioxide with a fractional percentage of oxygen and combustibles, the limits for these generally being stated.

The fuel and combustion air pass through a water-cooled, refractory-lined combustion chamber, a pre-cooler and wash cooler and finally a nylon filter before entering the compressor. In units provided with two-stage compression an inter-stage pressure cooler is provided to remove condensed water before the second-stage compression. After compression the gas is cooled, passed through a ceramic filter and is then available for use. The high pressure in the final stage of this and other units of its kind makes it possible to store the gas if required without further compression. Plants can be made automatic in operation, recycling cold gas to prevent overheating of the combustion chamber and again at the unit outlet when a reduced output is necessary.

In many processes carbon dioxide must be removed from the protective atmosphere and this can easily be done under pressure by solution in water—the method used in the *Mono*-type generator. It is possible to produce an atmosphere by this means with as little as 0.2% carbon dioxide, but if this percentage cannot be tolerated the water scrubber can be followed or replaced by an amine scrubber.

The carbon dioxide solution can be used as a source of this gas in cases where it is of value.

Generators of this type—embodying patents taken out by Dr. Ing. R. von Linde of Munich—are built in Britain by arrangement with the firm of J. F. Mahler, Esslingen/Neckar. Special features include automatic control of the combustion chamber temperature, enabling the atmosphere to be produced from either gases or distillate fuel oil, containing high percentages of hydrogen and carbon monoxide; and oxygen removal plant whereby an oxygen concentration of as low as 0.001% can be obtained.

Pure nitrogen free from carbon compounds can be obtained by using as fuel, in an exothermic generator, hydrogen and nitrogen gases produced in an ammonia cracking plant. Condensation of the water is followed by drying and oxygen removal.

Integrated plants

Standard plants are available for most duties, but it is often possible to integrate atmosphere preparation into the larger process for which it is required. In such cases considerable operational economies can be effected if the heat liberated can be usefully employed, and in plants of large output this saving amply rewards close co-operation between the designers of the various sections of the plant.

A generator just completed is a good example of such an integrated plant, in which the high-temperature waste heat is first used to superheat steam to 1,200°F. by the use of a radiation-type heat exchanger and the waste gases from the superheater chamber passed through an insulated brick-lined duct to enable it to be used to hot-jacket a reaction vessel. Such waste heat salvage combined with the similar use of differences in cooling-water temperature raise the thermal efficiency of the plant to a very high level.

Pressure hose and tubing. A four-page pamphlet from Polypenco Ltd., 68-70 Tewin Road, Welwyn Garden City, Herts., describes the various properties, uses and advantages of their *Nylaflow* pressure hose and tubing. The hose is a new, all-synthetic product, available in two alternative burst-pressure ratings of 5,000 and 8,000 p.s.i., and consisting of a specially formulated polyamide (nylon) inner tube, reinforced with high-tensile-strength yarn. It offers possibilities for such applications as hydraulic and pneumatic lines, and other lines handling fuel and oil, solvent or hot paint, high-pressure lubrication, *Freon*, high-pressure CO_2, etc. *Nylaflow* tubing, standard grade, is a polyamide tubing specially processed from type 66 to serve as a pressure tubing for air, gases or liquids. Tubing is available in two alternative burst-pressure ratings—1,000 and 2,500 p.s.i.

DRYING

By W. F. Calus, M.Sc.(Lwow), D.L.C.(Hon.), A.M.I.Chem.E.

(Department of Chemical Engineering, Loughborough College of Technology)

A 'CPE' Chemical Engineering Review

Fundamental problems; spray-drying studies; automatic control and other developments; new drying equipment

THIS review covers developments from approximately the middle of 1958 to the middle of 1959.* References to earlier investigations have been made when these constitute the beginnings of a continued research.

Investigations falling under the heading of basic research and fundamental studies are concerned with a number of subjects each confined to a very narrow field. This writer has not noticed any attempt to bring the findings of individual research workers under a common denominator so as to form a general theory. The few researches undertaken with the object of controlling the size of droplets and predicting the size of droplets after their passage through the drier are very practical aspects of spray drying.

Design of driers is still based on past experience of drying similar materials, although it is occasionally aided by laboratory or pilot-plant results. Recent developments in drier design lead to plant which is capable of drying a variety of materials and giving greater flexibility in operating conditions. Spare parts and accessories are now available in a large variety of constructional materials.

The economics of the drying operation are being improved by the gradual introduction of automatic control methods.

Food, pharmaceutical and biological products call for special drying equipment; thus there is a notable increase in the use of freeze-drying apparatus.

Fundamental studies

D. A. van Meel[1] gives a method for calculating the moisture content of a material being dried and the humidity of the drying air as a function of drying time and location of the material in a batch drier. The mathematical analysis leading to final practical equations is presented in an abbreviated form and is based on a number of simplifying assumptions, as, for example, that the adiabatic saturation temperature of the air remains constant. This method requires knowledge of the rate of drying *versus* moisture content curves determined under constant conditions by laboratory drying experiments. A numerical example is presented, but the validity of the method is not confirmed by any experimental work, although this is to follow in future.

Drying of highly porous, thick textiles—*Terylene* net fabric of open structure and woollen flannel of close structure—in an air stream were investigated by Nissan *et al.*[2] They found that during the falling rate period a constant temperature, the pseudo-wet-bulb temperature, is established throughout the wet cloth. The rate of heat conduction inward was equated to that required to produce the vapour diffusion outward, resulting in an equation for the calculation of the equilibrium temperature mentioned above. Close agreement between the experimental values of pseudo-wet-bulb temperature and those calculated from the equation point to its usefulness:

$$k(t_a - t_w) = 2.886 \times 10^{-4}(\varepsilon D_v)\,\lambda_w \left(\frac{P_w}{T_w} - \frac{P_a}{T_a}\right)$$

where the constant is appropriate for c.g.s. centigrade system of units and:

- k = thermal conductivity coefficient cal./(cm.)(sec.)(°C.)
- t_a = temperature of air stream, °C.
- t_w = pseudo-wet-bulb temperature, °C.
- ε = void fraction or porosity
- D_v = coefficient of vapour diffusion, sq.cm./sec.
- λ_w = latent heat of evaporation at temperature of water surface, cal./g.
- P_w = vapour pressure at water surface, mm.Hg
- P_a = partial pressure in air stream, mm.Hg
- T_a = absolute temperature of air stream
- T_w = absolute temperature of water surface

The paper includes 29 literature references.

Experiments on vacuum drying in a high-frequency electrical field and in a 'dipole radiation field' were carried out by Prof. Müller.[3] It has been shown that the methods have special economic advantages when applied to removal of the remainder of the moisture from a solid, corresponding to the lower part of the falling rate period of the drying curve. In the high-frequency field drying, the time required for the operation forms only a small fraction of that required in conventional methods of drying. Also the temperature of the operation is considerably lower. The advantages of the method are compared by means of experimental results with convection and vacuum drying.

N. Dietrich[4] investigated whether results obtained in drying artificially moistened grain are also valid for drying naturally damp material. The experimental results quoted show that for the same drying-air conditions the artificially moistened wheat dries faster. This difference in the drying rate becomes more pronounced with increase in the temperature of the air. During the experimental procedures drying air at 45 and 90°C. was used. Breakdown in the structure of the grain skin is suggested as being the cause for the lowering of the resistance to diffusion at the higher temperature.

With gel- and paste-like materials too high a rate of drying may cause the material to fracture and too low a rate of drying may be economically an unsound proposition. Görling and Beushell[5] published the results of physico-mathematical analysis undertaken by them which was supported by experimental work aiming at the prediction of the optimum drying conditions. During drying of these materials with an external heat supply a moisture gradient exists and this causes stresses and shrinkage. If the

* The author's last review of 'Drying' appeared in CHEMICAL & PROCESS ENGINEERING, 1958, **39** (11), 389-392.

magnitude of these forces can be correlated with the speed of moisture removal and the mechanical properties of the material, prediction of the optimum drying conditions becomes possible. The proposed procedure is illustrated with experimental results obtained in drying macaroni. The authors make frequent references to earlier work by Barkas on swelling stresses in gels[6] and swelling of wood under stress,[7] knowledge of which is helpful in reading this work. It has been pointed out also that high-frequency drying is not applicable to these materials as the method requires that for the vapours to escape from the interior of the substance to be dried a certain degree of porosity is necessary.

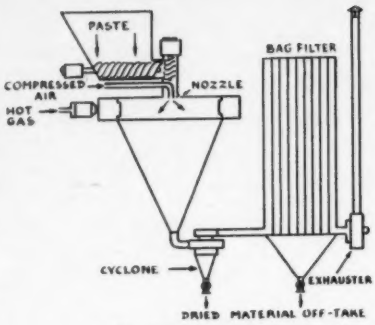
Drying rates

Drying rates were investigated when drying granular sand using air, superheated steam and mixtures of the two as drying media, in a small pilot-scale drier by Ju Chin Chu *et al.*[8] During the constant-rate period superheated steam gives faster drying rate than air, but at higher Reynolds numbers and in a fully turbulent region there is no substantial difference between air and superheated steam. The drying rates during the constant-rate period were correlated by the Colburn-type heat transfer equations, giving an average deviation of $\pm 12\%$ in the transitional zone and $\pm 9\%$ in the turbulent zone. Mixtures of air and superheated steam give intermediate drying rates, but mixtures with more than 50% superheated steam showed no appreciable gain in drying rate. During the falling-rate period the drying was faster with air alone than with the mixture. The paper includes 23 references.

Wheat and McLeod[9] present an empirically derived correlation for calculating the drying rates. The experimental work includes investigation into the drying rates of finely divided aluminium soaps and diatomaceous silicas in a tray drier.

Sprays and droplets

Crosby and Marshall[10] investigated the relationship between the size and density of spray-dried particles to the initial spray drop size as influenced by air temperature, feed concentration and feed temperature. Three distinct classes of feed were treated: a true solution (sodium sulphate), colloidal suspension (coffee extract) and a fine slurry (clay slip). The authors conclude that, depending on the kind of material being dried, particle properties of spray-dried materials can be varied within a limited range by changing suitably the three variables. The dry-particle diameter rarely equals the initial spray droplet size for the great majority of materials. Only the film-forming material dried at a high feed concentration and a temperature above the boiling point can be expected to give a dry particle of equal or bigger diameter than that of the initial spray droplet.



[*Courtesy: Chemie-Ingenieur-Technik*

Fig. 1. Spray-drier for paste-like materials (*after* Pöchmüller[21]).

A semi-theoretical equation, developed by Charlesworth and Marshall,[11] to predict the minimum time necessary to form a solid crust and thereby fix the final particle diameter was transformed to give an expression allowing the prediction of the ratio of the final to the initial drop diameter. However, the experimentally obtained values disagree somewhat with those obtained from the correlation.

Drop size of a conical spray from a single fluid nozzle can be measured by a simple test method devised by Binark and Ranz.[12] The fact that the drop trajectories when met by a cross-flow stream of air change their direction at a distance from the nozzle, varying with the drop size, coupled with the experimental determination of the liquid flux distribution at some distance below the spray sheet, form the basis of the method. The results obtained by this method agree very closely with the impactor method published earlier by Ranz and Hofelt.[13]

H. T. Watson Ltd.[14] published a booklet helping in the correct choice of spray nozzle. It gives a general guidance to droplet size ranges, graphs of the relation of droplet size to flow rates for various pressures and a list of common applications with recommended nozzle types.

Droplets resulting from impact of compressed-air spray atomiser issuing from two similar nozzles placed on the same axis were an interesting subject of studies of Tanasava *et al.*[15]

Instrumentation

Krischer and Mahler[16] developed an automatic recorder of drying rate. The essential part of the instrument is an analytical balance which is kept in equilibrium when a sample of the material being dried is counterbalanced by the upthrust obtained when a suitably dimensioned metal rod is partially immersed in water. On the loss of moisture the balance is kept in equilibrium by raising the water level to increase the degree of submergence of the metal rod. By a complicated system of mechanical and electrical relays the changes in the water level are translated into rate of drying and are registered on the recorder. The authors, however, do not suggest whether and how this instrument could be used for recording moisture changes in an industrial drier. It would appear to be a very useful instrument for laboratory investigations.

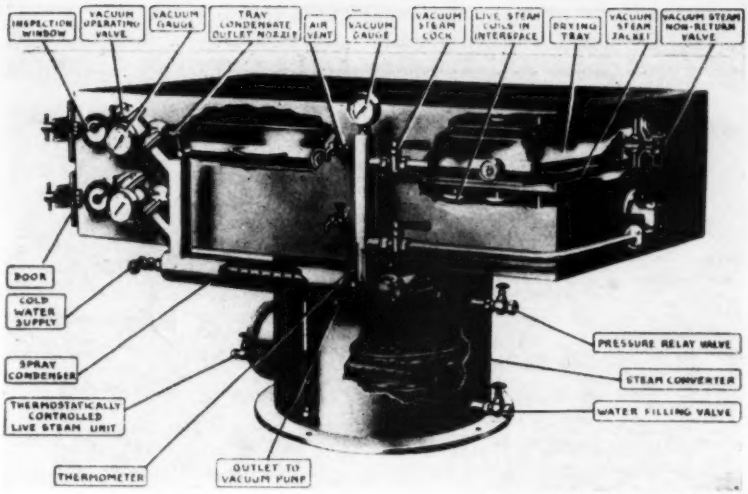
General literature on drying equipment

The trends in the design of large-scale freeze-drying equipment for foodstuffs are discussed by Forrest.[17] Physical properties of the foods, process procedure, heating methods and even instrumentation of the driers are considered. He also points out that process costs for freeze-drying food can be made competitive with those for preserving by canning or freezing. The article gives 12 references to literature giving experimental data on freeze-drying of various foods.

In a paper read to the Achema meeting, 1958, Schnell[18] discusses the newest trends in the development of drying equipment. Most of the drying equipment described is made in Germany. The author points to the following features introduced by the manufacturers: (*a*) laboratory apparatus is so designed as to allow the reproduction of full-scale plant conditions and to make the control of a manufacturing plant more flexible, and (*b*) driers are built so that they can be applied to the drying of various materials; this can be achieved by having a suitable set of additional drier parts.

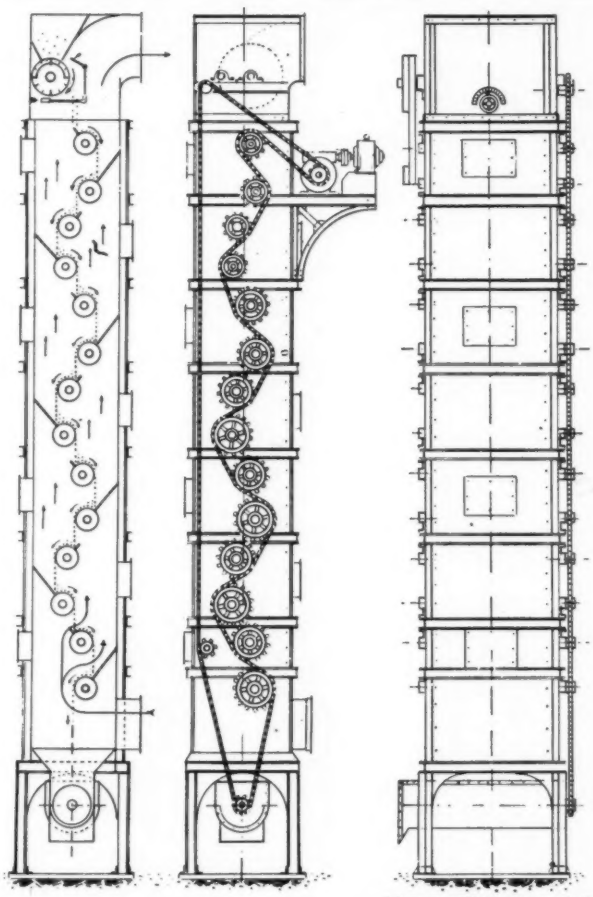
Appreciable progress has been made in increasing heat-transfer rates in drying heat-sensitive materials. Prevention of fire and explosion hazards and a tendency to equip driers for fully automatic control account, nowadays, for an appreciable proportion of the designers' effort.

A detailed review[19] is given of commercial driers ranging from complex spray-driers and freeze-driers to com-



[*Courtesy: Calmic Engineering Co. Ltd.*

Fig. 2. Cut-away view of two-compartment vacuum shelf drier.



[*Courtesy: W. C. Holmes & Co. Ltd.*

Fig. 3. Elevations and cross-section of the Conreur vertical roller coal drier, showing (*on the left*) the hot air flowing upwards through the descending coal.

plete simple electric ovens. Other types described are vacuum, rotary, film, pneumatic ring, turbo-tray and conveyor driers. The equipment reviewed covers developments of the last several years.

Another article,[20] describes two spray-drying installations used for drying ceramic materials and catalyst. Economic advantages over the older-type installations are analysed, *e.g.* spray-drying of catalyst replaces a three-stage process consists of filtration, steam-drying and granulation. The installations described, however, are only of large pilot-plant scale.

Drying equipment

Development of a new spray-drier for thick pastes and filter cakes is reported by Pöchmüller.[21] A screw feeder (Fig. 1) and a nozzle supplied with compressed air are used for feeding and atomisation of the material to be dried. The assembly also includes the conical vessel, cyclone separator and bag filter. The drier has already been used successfully for drying such materials as organic and inorganic dyestuffs, calcium carbonate, chalk and similar substances.

Trinity Equipment Corp., U.S.A.,[22] advertise a mass-produced compressed-air drier for throughputs up to 4,000 standard cu.ft./min., operating in the pressure range 60 to 6,000 p.s.i., giving dry air of a dewpoint of –200°F. and requiring no heat input for regeneration of the desiccant. The plant consists of two desiccant-filled chambers and appropriate switching valves and piping. A portion (10 to 25%) of the dry air is used continuously to regenerate the wet adsorbent in the second vessel. The nature of the desiccant is not disclosed.

Continuous vacuum freeze-drier and drying conditions for *Serratia marcescens* strain 8 UK are described by Maister *et al.*[23] The drier is fed with frozen pellets containing approximately 90% of moisture. Successful reduction of moisture to 1% with recovery of 80% of viable cells was achieved. The apparatus has a capacity of 50 g./hr. of dry solids. The paper gives 14 references to literature on freeze-drying.

A range of vacuum driers of the compartment type is recommended by Calmic Engineering Co. Ltd.[24] for materials of low moisture content, granules, powders, etc., including materials giving off toxic and explosive vapours. Hot oil, steam or hot water, circulating between the compartments, is the heating medium and the pipe connections are so arranged that part

of the drier may be operated while the other part is loaded or unloaded. The drier operates under an absolute pressure of 20 mm. Hg (Fig. 2).

The Conreur vertical roller coal drier is now manufactured by W. C. Holmes & Co. Ltd.[25] Coal is dried countercurrently with flue gases derived from any fuel and the amount of moisture in the coal leaving the drier can be controlled easily and no recirculation of dried coal is required. Low power consumption is another feature of this drier (Fig. 3).

Dunford & Elliott Process Engineering Ltd.[26] produce a packaged version of their rotary-louvre continuous drier. The new feature of the drier is that, besides drying, it is capable of roasting and cooling. The unit advertised has only 1 cu.ft. capacity. The unit is described and percentage moisture reduction for representative materials is quoted.

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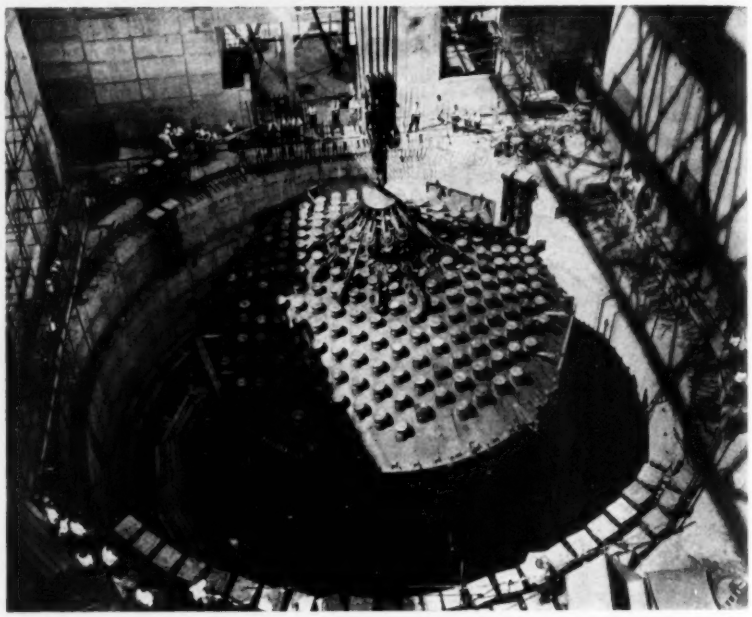
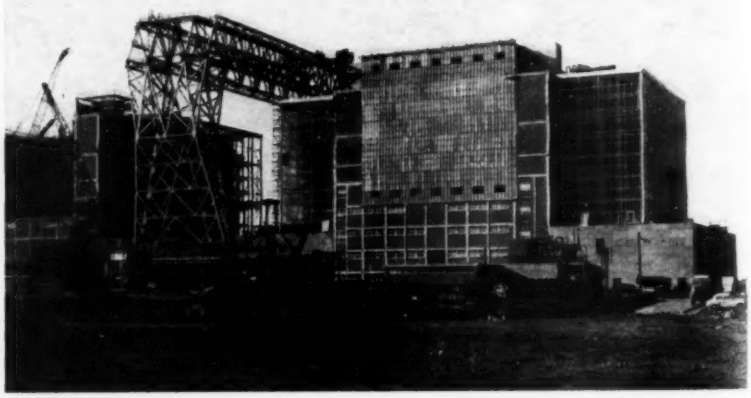
Progress at Bradwell



THE arrival at the site of the last of the 12 heat-exchanger shells for the steam-raising plant marked an important stage in the construction of the nuclear power station at Bradwell, Essex. The heat-exchanger vessels were supplied by Head Wrightson & Co. Ltd., one of the consortium of eight firms which is responsible for the design and construction of the Bradwell station. The 12 heat-exchanger vessels, each 20 ft. in diam. and nearly 100 ft. long, and weighing 200 tons, were towed by sea from Head Wrightson's Thornaby-on-Tees works to a point on the estuary of the River Blackwater, near the Bradwell site, and then towed to the site by tractor.

Heat for the 12 boilers will be supplied by two natural-uranium-fuelled, carbon-dioxide-cooled, graphite-moderated reactors which give the station an output of 300 Mw. The accompanying photographs give an idea of the stage the project had reached when visited by our correspondent recently. The building for No. 1 reactor was virtually complete, the spherical pressure vessel for the reactor had been stress relieved and was awaiting a pressure test, and the gantry for the charge/discharge machine was in position. In the reactor control rooms, the burst slug detection equipment and upper control rod gear had been installed.

The building for the No. 2 reactor was in a less advanced stage, but civil engineering work on the cooling pond was nearing completion and the turbine house was structurally complete.



Heavy Chemicals in Canada

The output of the Canadian chemical industry has reached an annual value of over $1,200 million, and the industry employs more than 50,000 personnel, according to a recent report issued by the Board of Trade in London. Salient features of Canada's production of heavy chemicals, fertilisers and petrochemicals are briefly summarised below.

AN analysis of the Canadian chemical industry in 1957 showed that there were some 193 plants producing heavy chemicals, coal-tar distillation products, compressed gases, fertilisers and primary plastics, while there were 948 plants producing chemicals of other denominations. Just under 50% of Canada's chemical plants are located in the Province of Ontario and about 32% in the Province of Quebec.

There are two major factors behind the accelerated growth of the Canadian chemical industry during the past 20 years; firstly, the spur provided by the war and, secondly, the fast expansion of the metal-mining, pulp and paper, and iron and steel industries. Not only has the chemical industry grown in physical size but it has also achieved, in the past ten years, a substantial broadening of its base, with the result that Canada now produces virtually all the chemicals she herself uses in large volume. The most striking development, as might be expected, has been the growth of organic chemicals derived from petroleum raw materials. The post-war years have also seen an acceleration of the trend to 'giantism,' and a relatively few companies have emerged to dominate the field; in basic chemicals, for example, over 80% of Canada's output is produced by only 16 companies.

A high rate of capital spending has been maintained in recent years. It is estimated that $835 million have gone into new plant capacity in the post-war period; of this figure 80% has been spent since 1950. One phase of expansion was completed in 1953 and, after a short period of consolidation, the industry started on a yet bigger expansion which carried it through 1958.

A study commissioned in 1957 by the Royal Commission on Canada's Economic Prospects (the Gordon Commission) forecast that Canadian demand for chemicals may reach between $5,500 million and $6,500 million in 1980, *i.e.* five times the present size.

Acids, alkalis and salts

In 1956, output of acids, alkalis and salts, calculated in millions of dollars, was as follows:

Acids	24.0
Calcium compounds ..	18.0
Sodium compounds ..	36.4
Organic chemicals ..	94.2
Chlorine	6.5
Other chemicals ..	14.4
	193.5

Of the 48 plants contributing to these figures, 25 were engaged in the production of large-volume chemicals for sale or resale to other industries. Of the 16 companies accounting for 80% of this industry's production, ten are U.S. controlled, two U.K. controlled and only four are divisions of major Canadian chemical concerns. Much of this section of the industry serves the needs of resource industries, particularly the metal and metal by-products fields. Accordingly about four-fifths of plant capacity is in Ontario and Quebec, although in recent times, natural gas availability in Alberta has caused some new location of plant in that province.

Chlorine, sodium hydroxide and sulphuric acid now account for about 20% of the output of the 'acids, alkalis and salts' group. Over 40% of the production is organics; this production contrasts with a 20% output of organics and 80% inorganics in 1939. In organics Canada is markedly self-sufficient, but organics are not produced in as nearly complete a range as are inorganics. Heavy and fine organic chemicals produced in Canada number only about 500 in comparison with over 7,000 in the U.S.A.

Coal-tar distillation

The structure of this wholly Canadian-controlled industry is simple. Of the 11 refining plants in operation (Ontario 5, Quebec 3, British Columbia 1, Nova Scotia 1, Manitoba 1), five are owned by one major roofing and building products firm, four by another such concern and the remaining two by companies operating single plants. With the disappearance of by-product coke installations, because of the availability of natural gas, these refining plants will depend more and more on Canada's major steel and primary metals producers. These latter producers, in turn, as they increase their coking operations, will probably give more attention to the conversion of their surplus gas and coal-tar residues into organic chemicals, although they will remain well behind the natural gas purifiers, the oil refineries and the petrochemical operators in the production of aromatics.

In Canada, the production of coal-tar products has lagged behind that of other major countries and has never progressed much beyond the first stage of separation (into pitch, creosote oils and tars). Dyestuffs, pharmaceuticals, etc., of coal-tar origin have consistently been imported, usually in bulk. The coal-tar distillation industry has never been protected, has lacked in basic research and has had to compete in a small-population market with more efficient and larger foreign competitors, e.g. U.S.A., U.K., West Germany, Switzerland. The levels of import (about $3.3 million annually) and exports (at $0.5 million) and domestic production (about $13 million) have changed little in recent years.

Compressed gases

There are only three major firms in Canada engaged in compressed gas production, and these three, one specialising in carbon dioxide and two in acetylene and oxygen, operate 40 of Canada's 55 plants. These plants are usually small and are scattered across Canada close to the consuming centres in which they are required, there being little inter-regional trade in industrial gases. About half the value of the present output from Canadian gas plants is in oxygen. Acetylene accounts for about one-third and carbon dioxide for less than one-sixth.

The considerable capital expansion in the years 1956, 1957 and 1958 is accounted for in part by tonnage oxygen plants for oxygen steel operations in Hamilton and Sault Ste. Marie, and by the industry's concentration on new facilities for liquid gas production and distribution as opposed to the traditional compressed gas operations. It is probable that techni-

cal developments in the steel and other metallurgical industries in Canada may call for considerably increased production of oxygen. Acetylene demand is likely to grow with increasing construction activity and demand for carbon dioxide to grow with increasing food distribution and processing. A substantial rate of growth for this industry is forecast.

Fertilisers

Canada's fertiliser industry has long been one of the most important sectors of her chemical production. In the 1940's, Canada became the world's second largest exporter of nitrogenous fertilisers. From the first, the industry has been closely associated with resource development. The by-products of dynamite (for the mining industry), the by-product sulphuric acid from smelting operations, the availability of cheap hydro-electric power for nitrogen fixation (as cyanamide and ammonia) and more recently, for the manufacture of ammonia from natural gas, have all contributed to make Canada one of the world's leading fertiliser producers, with a production one-seventh that of the U.S.A. Ammonium nitrate, ammonium phosphate and ammonium sulphate account for more than half of Canada's fertiliser industry output. Next in importance are superphosphate and calcium cyanamide, whose production is reported in the returns of the heavy chemicals industry. That this fertiliser industry has, however, reached a plateau is indicated by $17 million spent in 1956 followed by capital expenditures of only $1.6 million in both 1957 and 1958.

Canada's eminence in fertiliser production is remarkable in that it is not founded on phosphate rock nor potassium chloride of native origin. Her exported fertilisers sell abroad competitively because of cheap and plentiful natural gas and power, and particularly because of low cost by-product sulphuric acid. Western Canada fertiliser production is dominated by Canadian-owned mining and smelting concerns. Eastern Canada producers include a branch of the sole North American maker of cyanamide and three other major fertiliser concerns, two United Kingdom and one U.S. controlled.

Plastics

The 1956 value of synthetic resin production, including casein, vinyl, polystyrene, alkyd, phenol-formaldehyde, urea-formaldehyde, sodium carboxymethylcellulose, polythene, cellulose acetate, nylon flake, etc., was $50 million. Production now comes from 29 plants (Ontario 13, Quebec 9, Alberta 4, British Columbia 3), of which 16 are U.S.- and two U.K.-owned. Canada, now the world's sixth largest producer of plastics, supplies about two-thirds of her own requirements. Future growth in primary plastics is assured by the 1958 capital outlay of $16 million ($10 million more than in 1957) to extend capacity in polythene, epoxy resins, phthalic anhydride and polyesters, with much of this extension in polythene plant. Despite the increase in production in 1955, 1956 and 1957, however, the mounting use of plastics in Canada gave rise to increased imports of primary plastics and manufactures—chiefly from the U.S.A.

Synthetic rubber

Synthetic rubber production by Polymer Corporation Ltd., Sarnia, a Crown company, the most complete and fully integrated of the North American war-time synthetic rubber plants, now exceeds 130,000 short tons p.a. Of this about 70,000 tons are exported. Future growth of the Sarnia concern is assured as low-cost hydrocarbons become available from Western Canada oil and gas developments, and as by-products from the expanding petroleum refining industry in Sarnia. Present plans call for a boost in production to 140,000 tons in the near future. A new latex plant equipped to turn out a wide range of latices, with particular emphasis on foam rubber, went into production in early 1958, to be followed soon by a seventh finishing line added to the existing copolymer unit. Polymer Corporation, as might be expected, has other extensive long-range plans for a variety of synthetic rubber projects.

Explosives

There has been significant recent demand for explosives to be used in various industrial development programmes, *e.g.* the St. Lawrence Seaway; coastal shipping lane clearing; tunnelling operations; natural gas pipeline extensions. For these and like demands, 168 million lb. of chemicals are going into the manufacture of some 100 million lb. of explosives in Canada. An additional 20 million lb. of blasting-agent type explosives, also being produced in Canada, require a further 18 million lb. of chemicals. Most of the chemicals required in this industry (nitric acid, glycerol, glycol and ammonium nitrate) are produced in Canada. Sodium nitrate, however, is imported. There are eight plants making commercial explosives, the latest being a $7 million plant in North Bay for dynamite production, and a Calgary plant for continuous nitration of glycerol.

Petrochemicals

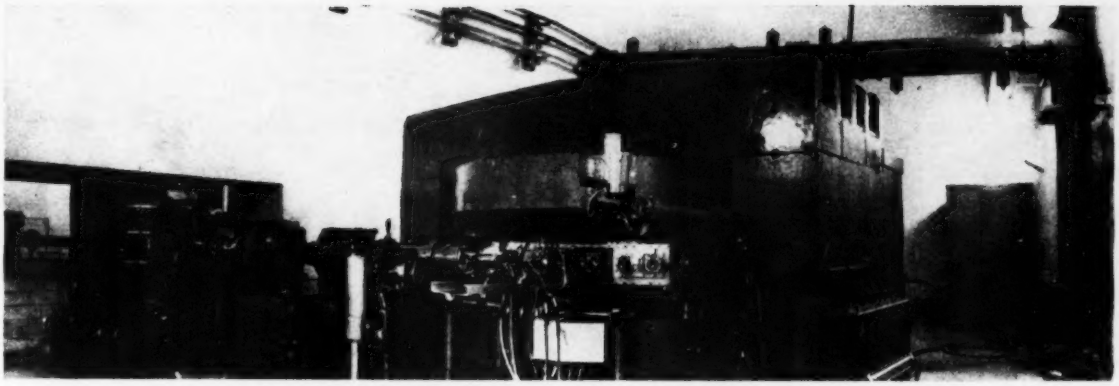
In Canada the bulk of petrochemical operations is based on crude oil which supplies about 60% of the raw materials, with natural gas and gas liquids supplying the remaining 40%. There are three main producing centres for petrochemicals: Sarnia in Ontario, Montreal in Quebec and Edmonton in Alberta. The heaviest concentration of petrochemical plants is at the two largest refining centres—Montreal and Sarnia—where liquid petroleum fractions are available in considerable quantity, and of these centres Sarnia has the largest capital investment. Further development of petrochemical operations in Western Canada will follow upon the build-up of certain hydrocarbons, such as propane, butanes, ethane and hexanes, once the Trans-Canada gas pipeline reaches high volume operation and draws heavily on wet gas fields in the West.

In all, 18 plants—Alberta 9, Ontario 5 and Quebec 4—representing an investment of over $450 million, comprise the petrochemical industry in Canada. Financial control of these is as follows: three by Canadian, twelve by U.S. and three by U.K. interests.

In the period 1947-54, one-half of the expansion (8% annually) in output of the acids, alkalis and salts industry was in petrochemicals, excluding sulphur, rubber, plastics and fertiliser production. The other half was in line with the average rate of expansion of manufacturing generally. Hence there is justification for stating that the growing part of the heavy chemicals tree is petrochemicals.

The foregoing information is based on a report prepared by the United Kingdom Trade Commissioner Service in Canada. Enquiries should be addressed to the Board of Trade, Commercial Relations and Exports Department, Horse Guards Avenue, London, S.W.1.

Electrostatic separator, type OH, described in an eight-page illustrated publication (No. 7204) from Sturtevant Engineering Co. Ltd., Southern House, Cannon Street, London, E.C.4, is claimed to have a very high capacity and great sensitivity. Three standard units are built and the largest can deal with 10,000 lb./hr. on some materials.



Cyclotron at the Atomic Research Institute near Peking. This, with the heavy-water reactor, is being used to train Chinese scientists.

Atomic Energy in China

(Specially Contributed)

When the Communist Government of China came to power in 1949, *China had not even made a beginning in atomic research. In recent years, however, with help from the Soviet Union, notable progress has been made in training scientists for work in this field, and in providing them with the latest types of experimental equipment.*

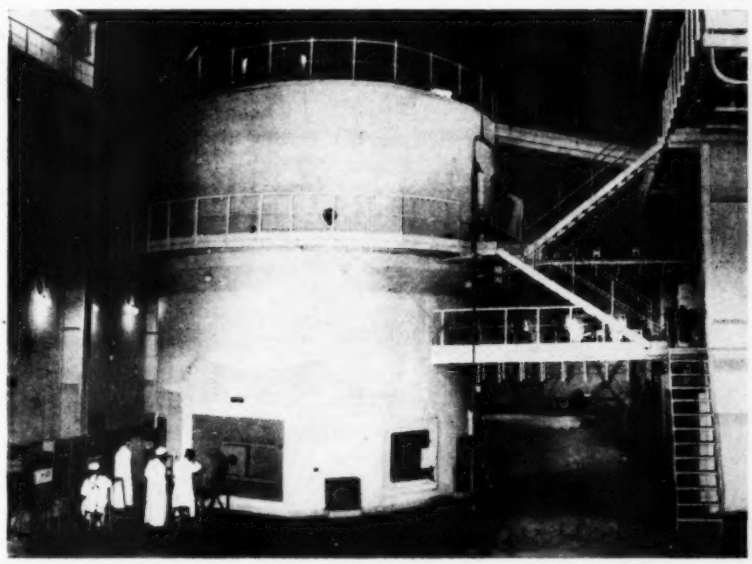
CHINA recorded her first advances in atomic research in 1957 when, with the assistance of Soviet experts, work was almost completed on the 7,000-kw. experimental heavy-water reactor and the 25-MeV. cyclotron. A pressure-type electrostatic accelerator, a high-voltage multiplier and a β-ray spectrometer were also built during the year.

This progress is impressive since it was only in 1956 that the China's Communist Party's call for a ' march on science to ensure that China will catch up with or approximate the world's advanced levels in the most important branches of science and technology in 12 years ' led to the launching of the 1956-67 plan for the development of science and technology, including atomic energy research.

According to Nieh Jung-chen, chairman of the Planning Committee for the Development of Science: ' We should and absolutely can master, in not too long a time, the newest techniques concerning atomic fission, thermonuclear reaction, the use of atomic energy in all fields, radio and electronics, jet propulsion, rockets and the conquest of the outer space. We should also master the new technique of manufacturing high-strength metallic and non-metallic materials resistant to high pressure, high temperature and radiation.'

Training reactor

The reactor and cyclotron are at the Atomic Research Institute near Peking. The Russians helped to train Chinese scientists and technicians and supplied complete sets of equipment for the reactor. Soviet experts also supervised the installation and initial operation. The reactor has a thermal power range of 7,000 to 10,000 kw. By the beginning of this year it had produced 33 kinds of radioisotopes,



A view of China's first atomic reactor, of the heavy-water type.

including Cobalt-60, Sodium-24, Phosphorus-32 and Calcium-45. Probably the most important function of the reactor, however, is to train key scientific and technical personnel in the design, installation and maintenance of the various types of reactors that China plans to build.

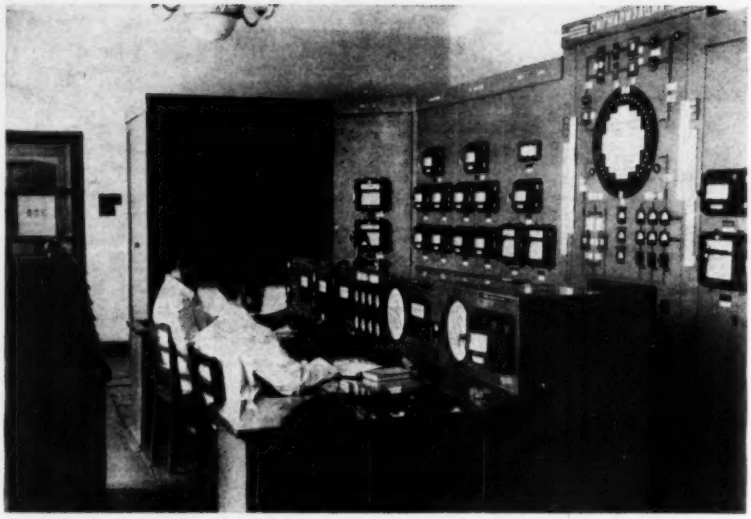
The cyclotron can accelerate α particles whose energy can reach 25 MeV. A pressurised electrostatic accelerator built by the Chinese was also completed in the latter part of last year and is now in use for experiments. It can accelerate protons whose energy can reach 2.5 MeV.

Nuclear and electronic equipment

The first computer to be built in China is in operation at the Academy of Sciences. A small universal electronic digital machine, it has 4,000 germanium diodes and 800 electron tubes. It is being used for short-range weather prediction, non-steady flows, geodetic problems, analysis of stress in the designing of dams, and problems of atomic energy and aerodynamics.

China's advances in nuclear research were highlighted at a national industrial and communications exhibition which took place in Peking last September. On display, in addition to models of the atomic reactor, cyclotron and electrostatic generator, were numerous items of Chinese-made laboratory equipment, charts and uranium ore specimens. There were models of a 5-MeV. betatron and a 1-Mw. experimental swimming pool water reactor. Laboratory equipment shown included various spectrometers and isotope separators, trochotrons, counter tubes, counter telescopes and nuclear emulsion plates. (The Chinese claim that their nuclear emulsion plate surpasses the comparable British product.) Also at the exhibition was a Chinese-made 100-channel pulse-height analyser which can analyse up to 50,000 pulses/sec., and also a 50-channel unit. A magnetic-beam switching tube designed by Chinese scientists is a new type of trochotron which can be used in remote-control automation and telecommunications systems and electronic computers. A cloud chamber, a millimicrosecond oscilloscope, a γ-ray therapy apparatus for treating tumours and a Cobalt-60 flaw seeker were also included in the display.

In honour of China's National Day last October, research workers of the Chinese Academy of Sciences gathered in a big Peking rally ' to present their gifts ' to mark the occasion. Of about 2,100 achievements in research, some 230 were claimed to have either reached or surpassed international levels. ' Gifts ' from the Institute of Atomic Energy included two theses on weak interactions between nuclei and elementary particles, vacuum pumps capable of pumping 40,000 litres/sec. of air, a multi-purpose betatron and a universal scaler. At the same ceremony gifts presented by the Institute of Geology included an *x*-ray fluorescent spectroscope for analysing rare-earth elements.



Central control station for the heavy-water reactor. Significantly, the inscriptions on the panels are in Russian.

Experimental accelerators

Other successes reported by the Chinese are interesting not only for the light they shed on the progress being made, but also as pointers to the scope of research work being carried out in various parts of the country. The following are amongst developments reported in the Chinese technical press during the latter part of 1958 and the first six months of 1959.

A small cyclotron, capable of accelerating particles to energies of 60,000 electron volts, has been produced by teachers and students of the physics department of Szechwan University. The cyclotron, which is being used for chemical experiments, was produced with the assistance of industrial enterprises and engineering institutes in Chengtu.

An electron static accelerator has been produced by the Wuhan Institute of Atomic Energy of the Chinese Academy of Sciences. It is being used in industry, agriculture and medicine. The Wuhan Institute was set up last year by the Wuhan branch of the Chinese Academy of Sciences, the Wuhan University, the Central China College of Engineering and various factories in the city.

An experimental atomic reactor, the first to be made in a Chinese higher educational institution, has been built by faculty members and students of Nankai University in Tientsin. It is a small homogeneous reactor with a reflecting layer for use in teaching and research. It has a maximum permissible power of 3,000 mw. Through the neutron current and β- and γ-rays released from the reactor, various experiments to determine the properties of neutrons can be carried out and the characteristics of various radiations can be studied. A double-function β spectrometer to study the properties of isotopes and nuclear structure has also been made by Nankai University.

China's first induction electron accelerator was trial-produced in September of last year by teachers and students of the department of engineering physics at Tsinghua University (China's leading polytechnic institution) in Peking. The accelerator (5 MeV.) is being used in research, industry and medicine. Apart from a few electron tubes which were imported, the rest of the equipment in the accelerator was made in China. Soviet experts assisted on the project.

Last November a 10-MeV. inductive accelerator was made at the Central China College of Engineering in Wuhan. The accelerator was reported to have been produced ' after 24 days of hard work.'

On the eve of National Day last

(*Concluded on page* 404)

WHAT'S NEW

Plant • Equipment • Materials • Processes

CPE reference numbers are appended to all items appearing in these pages to make it easy for readers to obtain quickly, and free of charge, full details of any equipment, machinery, materials, processes, etc., in which they are interested. Simply fill in the top postcard attached, giving the appropriate reference number(s), and post it.

Centrifugal pumps

Open-impeller-type centrifugal pumps, specially designed to handle slurries, paper stock, liquids containing small solids, and viscous liquids as well as clear liquids, have been introduced by Worthington-Simpson Ltd.

Capacities are from 10 to 360 gal./min. and heads up to 86 ft., depending on capacity. **CPE 1364**

Fractionating tray

Capacities equal to those of a well-designed sieve tray, and an efficient operating range exceeding that of bubble-cap trays, are claimed for Koch *Flexitrays*, for the manufacture of which Archibald Low & Sons Ltd. have recently been granted a licence.

The *Flexitray* has liftable caps of approximately 2 in. diam. which operate like check valves. They are limited in lift and are guided by four-posted, plate-stamped spiders which are clinched to the deck. Conventional downcomers of either chord or conduit type are employed.

Normally two weights of caps are used on a tray, alternating in rows parallel to the outlet weir and serving to ensure vapour distribution at low vapour rates in spite of out-of-level installation. The lighter caps open during the first 20 to 30% of tray capacity and the heavier caps from this range to 50 to 70% of capacity. At higher rates all caps are fully open and thrust against the hold-down spider.

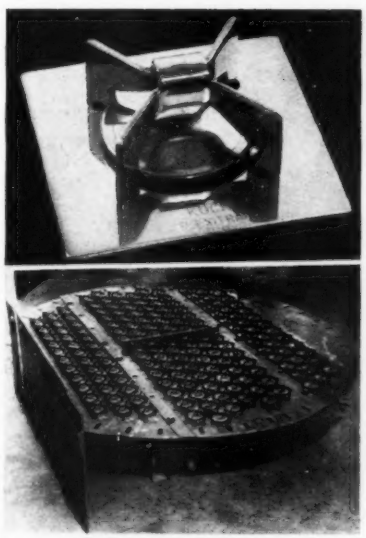
According to the suppliers, operation may be compared to a sieve plate except that the highest vapour velocity issues from the slot in a horizontal direction to overcome the sieve tray's tendency to blow dry or cone in certain operation ranges. When all caps are open the *Flexitray's* contacting pattern simulates a bubble-cap tray but, it is stated, the lack of hydraulic gradient causes the vapour to flow at more uniform rates through all sections of the deck. **CPE 1365**

Aids gas flow measurement

The size of an orifice plate for measurement of gas flow is calculated for one temperature and one pressure; any variation in either will affect the accuracy of the final reading. In most cases variations are small and the effect on metering accuracy is negligible. However, instances do arise in which large changes in either pressure or temperature, or both, are encountered and it is then necessary to apply a correction.

A system providing automatic compensation for temperature and for pressure changes during gas flow measurement is supplied by Honeywell Controls Ltd. The Sorteberg force bridge pneumatic relay is used, this being essentially a multiplying and dividing unit which corrects the flow signal.

The pressure and temperature transmitters are calibrated from absolute zero to the maximum values for which compensation is required. Transmission is such that zero absolute is 3 p.s.i., whilst the maximum reading gives 15 p.s.i. **CPE 1366**



Photos illustrate the 'Flexitray': (*above*) close-up of the liftable cap; (*below*) a complete tray.

Grounds for investigation

Wet or dry grinding of specimens can be accomplished with a grinder consisting of a ground-glass plate and a *Perspex* frame for holding four grades of waterproof abrasive papers which are washed continuously by water sprays incorporated in the head of the frame. The assembly is mounted in a polythene tray with a drain exit.

Specimens up to $1\frac{3}{8}$ in. diam. can be ground and worn papers are replaced in a few seconds. Continuous water feed obviates the necessity to rinse the specimen when changing from one grade of paper to the next, and the abrasive effect of the paper is maintained since the loose products are washed away.

The *Nashton* pre-grinder, which costs £12 net, is available from Nash & Thompson Ltd. **CPE 1367**

Automatic control of acid handling

Remote control of the transfer of concentrated hydrochloric acid in measured quantities from storage to process vessel has been achieved in an industrial installation now nearing completion. Here, storage tanks outside the factory building are elevated sufficiently to give gravity feed to the measuring vessels, which consist of calibrated, vertical cylinders, fitted with electronic level detectors coupled

to the control system. Movement of acid in the system is effected by compressed air, by way of specially designed pinch valves operated by high-pressure air cylinders and servos. All pipelines are of acid-resisting plastic material or rubber-lined steel pipe.

An electric, push-button system controls the entire process automatically. When the measured charge has been admitted the valves shut and the measuring vessel is vented so that it is filled by gravity and available for the operation to be repeated. In this installation two measuring vessels each feed a battery of eight process vessels with 250-gal. charges. The 16 process vessels are subsequently emptied by similar control methods.

The system, designed by Liquid Systems Ltd., is protected by interlocks from possible errors in operation and visual and audible signals are provided to give clear indication of what is happening at any given moment. Overriding direction of the whole process is exercised in this instance from a programme control panel fitted in the production manager's office.

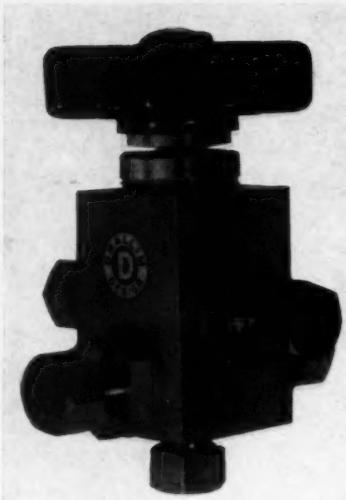
CPE 1368

Stack with no fumes

A hand-propelled stacking machine fuelled by propane gas is claimed to have lifted 60 tons/hr. at a cost of approximately 8d. The operating lever for the lifting movement is linked with the throttle of the engine in such a way that the throttle is only opened during the actual lifting operation and the engine reverts to 'ticking over' during lowering and waiting. The 10-lb. *Bottogas* containers are exchangeable, the refills costing 8s. 6d.

Lifting capacity of the stackers is up to 7 cwt. at a rate of 40 ft./min. It is claimed that the absence of obnoxious fumes makes it possible to operate them in locations where internal-combustion engines are undesirable. **CPE 1370**

Propane-gas-fuelled stacker in action.



SELECTOR VALVE

The selector valve illustrated above has a common inlet connector which will distribute gases and liquids to any one of the four ports while the other three remain positively closed. The design is adaptable to other arrangements and the valve is one of a range covering two- to six-way distribution in various ways. Working pressure: high vacuum to 200 p.s.i. Makers: Drallim Industries Ltd.

CPE 1369

Laboratory deioniser

Evolved from the *Elgastat* B.102, a new laboratory deioniser by Elga Products Ltd. has a meter panel of anodised aluminium, waterproofed conductivity meter and switches and a meter movement designed for greater accuracy at both ends of the scale. 'O' rings replace the washer between storage tank and cartridge, a drip-proof control valve is fitted, and a polythene dust cover forms part of the unit. The flow rate is 15 to 18 litres/hr. No regeneration *in situ* is required.

CPE 1371

Variable-flow pump

A new, hydraulic, variable-flow pump is of the multi-piston type operated by camshafts which run in roller bearings. Pairs of pistons operate with common suction and delivery valves and the relative position of the camshafts is altered to give an infinitely variable flow.

Full pressure is produced down to zero capacity and the pump may be run in either direction to suit the prime mover. Capacities are from 7½ to 50 gal./min. with pressures up to 2,000 p.s.i. Sutcliffe Hydraulics Ltd. are the makers. **CPE 1372**

Air velocity indicators

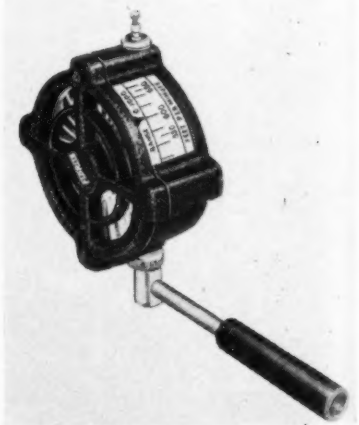
Two low-priced air velocity meters from the Shandon Scientific Co. Ltd. are the *Florite*, a bridled vane anemometer, and the *Floret*, a small pocket indicator.

The *Florite* is a circular instrument with a die-cast housing, 4 in. in diam. and 1¾ in. deep. The rotating peripheral scale, 8 in. long, gives direct readings in ft./min. or m.p.h. Two scale ranges are available, 0 to 1,000 ft./min. and 0 to 3,000 ft./min., the latter scale also bearing graduations in m.p.h. The readings are automatically averaged over an area 3 in. in diam. and accuracy is guaranteed within 2% of full-scale reading. A zero adjustment is provided.

The *Florite* is available in two models, one having a special scoop for measuring air flow from square or circular ceiling diffusers or louvres.

The *Floret* pocket instrument provides instant direct readings on a 2¼-in.-long sector scale graduated in equal-sized divisions from 0 to 1,000 ft./min. It is entirely self-contained.

CPE 1373



'Florite' air velocity meter.

They get cracking on ammonia

Using a specially developed catalyst, claimed to have exceptionally long life and high activity, high-temperature ammonia crackers are now being produced by the gas atmospheres division of the Incandescent Heat Co. Ltd. to the design of the Drever Co., U.S.A. These plants have outputs from 150 to 5,000 standard cu.ft./hr. and are produced in ten standard sizes. **CPE 1374**

Scratch and heat cuts glass tube

A glass-tube cutter for cutting hard (borosilicate) or soft glass, up to 3 in. in diameter, has been introduced by Electrothermal Engineering Ltd.

No special skill is required: the tube is rotated against the cutting wheel and the resulting scratch mark is then held against the hot wire, localised heat causing the tube to part neatly. An adjustable backstop makes sure that the scratch is cut accurately around the circumference of the tube. Price: £14 10s. **CPE 1375**

Sorts and separates

The *Vibragem* blown-air densimetric separator, marketed by Henry Simon Ltd., accurately separates and classifies all granular materials of closely related specific gravity. It permits simultaneous classification, grading, stone removal and purification.

The materials under treatment are fed on to a triangular screen which oscillates rapidly. Filtered air is introduced from underneath and holds the materials in suspension over the screen while separation takes place. A second screen of wire gauze is incorporated to give uniform air distribution. Capacities of the machine vary according to the specific gravity of the materials and on products handled so far the throughput has varied between 800 and 3,300 lb./hr. **CPE 1376**

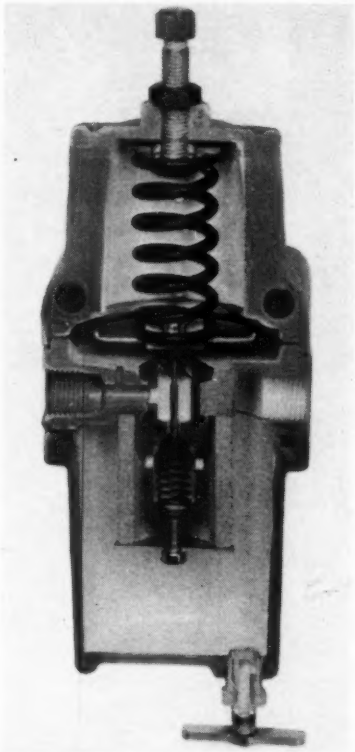
Densimetric separator.

Air filter regulator

A new air filter regulator set comprises a large-capacity dripwell, porous ceramic cartridge-type filter, pressure-reducing valve and safety relief valve, all in one compact lightweight unit. The body is of die-cast aluminium with two mounting bolt holes.

Outlet and inlet pressure gauges can be fitted and, if necessary, the outlet connection can be orientated in three alternative positions. The maximum inlet pressure is 250 p.s.i., the reducing pressure range 5 to 40 p.s.i., weight 2½ lb., and overall height 8¾ in.

Suppliers: Crosby Valve & Engineering Co. Ltd. **CPE 1377**

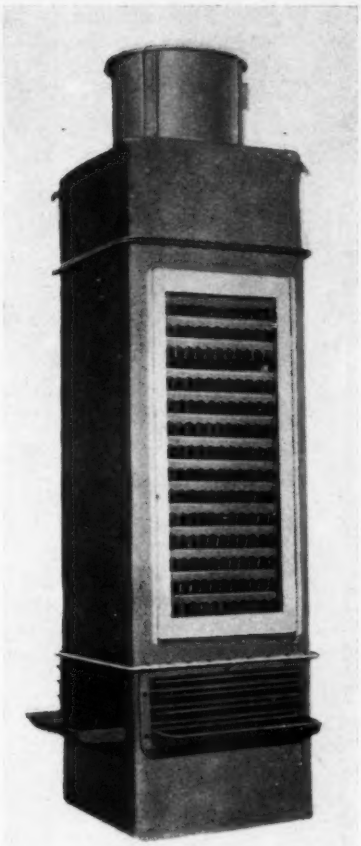


Cut-away view of air filter regulator.

New engineering plastic

A new chemically inert thermoplastic material *Polypenco* K.51, is claimed to possess excellent mechanical strength, temperature resistance, chemical resistance and dimensional stability. A chlorinated polyether derived from pentaerythritol, it is inert to almost all alkalis, solvents, chlorides, and inorganic acids, and is suitable for bearings, valve seats, seals, gaskets, washers, impellers and other parts operating under severe corrosive conditions. The material is also completely non-hygroscopic and possesses excellent outdoor weatherability.

Polypenco K.51 is a comparatively rigid form stable material, having a tensile strength of 6,000 p.s.i. and a Rockwell hardness of R100. Makers: Polypenco Ltd. **CPE 1378**



Packaged cooling tower, described below.

Ready-made cooling towers

A complete packaged cooling tower, small enough to be transported in a light lorry, has been designed by Film Cooling Towers (1925) Ltd. The basin, shell and splash tray are made of resin-bonded glass-fibre and the tower operates on the induced-draught principle. The packing is of the *Film Flow*

design, being composed of a number of horizontal trays of parallel laths, each layer being at right-angles to the trays immediately above and below it. The water is discharged from spreader troughs which run along the entire length of the tower and it flows down the grid packing, changing direction through 90° every 2 in.

The internal packing is of impregnated timber.

The unit is supplied ready for immediate operation, requiring merely to be coupled after the ground has been suitably levelled. Since the pond basin is an integral part of the tower no concrete or steel tank and foundations are necessary. Capacities of these towers range from 300 to 5,000 gal./hr. **CPE 1379**

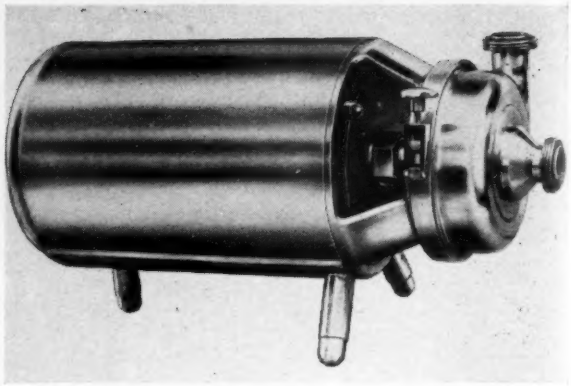
Plastic pipe for effluents

About 1,000 ft. of large-diameter, reinforced-epoxide pipes have been used in the reconstruction of drainage systems at Battersea, London, electricity generating station, replacing ceramic pipe in a system which carries effluent from flue-gas washing plant, located in two of the four chimneys, to a treatment unit from which the effluent is eventually discharged into the Thames.

The effluent from the flue-gas washing plants, after discharging the larger ash particles into settling tanks at the base of each chimney, contains a percentage of sulphuric acid and owing to its remaining ash content is highly abrasive.

According to information received from Bakelite Ltd., the reconstruction work involved the replacement of the drainage system from one chimney, and the renewal of certain lengths which had become affected or damaged in the system from another chimney. All the new pipes, man-hole covers and fittings were made from *Bakelite* epoxide resin, reinforced with glass fibre and *Terylene*, the latter giving added abrasion resistance to the inner surface of the pipes. The pipework was manufactured and installed by Mondip (Chemical Engineering) Ltd.

Enquiries concerning epoxide pipe of this type should be addressed to Bakelite Ltd. or to CPE Enquiry Bureau, quoting the reference: **CPE 1380**



One of the 'Puma' range of stainless-steel pumps.

Stainless-steel pump

The *Puma* stainless-steel pump has a stub shaft attachment which allows it to take most of the appropriate standard types and makes of motors. There is also provision for alternative and easily changed rotating seals for any conditions. Water cooling can be applied to any of these seals.

The pumps, made by A.P.V., are available in sizes of 1½, 2 and 2½ in. for various motor horsepowers and with various sizes and types of pipe connections as used in the potable liquid industries. **CPE 1381**

Compact control

The *Mini-Line* system of pneumatic control is aimed at reducing the area of the panel and the area of the control room; the elimination of high-pressure piping in the control room; and removal of the hazard due to the proximity of electrical controlled equipment. It is claimed that lower erection costs are achieved by the use of small-bore, low-pressure tubing between transmitter and receiver. The equipment is also claimed to provide improved operations when large distances separate the transmitter and control room. Design is adaptable to the functional arrangement of the control panel.

The principle used is that of the force balance with metallic bellows. The five basic components of the system are:

(1) pneumatic transmitters, including square-root-extracting transmitter;
(2) indicator receivers, circular or vertical edgewise, recorder receivers, single- or multiple-pen;
(3) control relay;
(4) manual-automatic selector valve; and
(5) regulating unit, complete with positioner.

Further information can be obtained from Bailey Meters & Controls Ltd., or by making use of the reply-paid card, quoting: **CPE 1382**

HERE'S A SHAKER

This laboratory shaker, designed for silent operation, has a 1½-in. stroke and it is claimed that a rate of 275 to 280 oscillations/min. can be obtained. The tray is made of sheet steel and is rubber-lined. It is supported on four rollers and is oscillated by a connecting rod from a crank-shaft, driven by a geared motor via a V-section, canvas-reinforced rubber belt. Racks are held rigidly in place by a quick-release locking lever. An attachment to hold bottles is also available. Overall dimensions of the equipment, made by Baird & Tatlock (London) Ltd., is 30 in. × 11 in. × 8 in. high. **CPE 1383**

Platinised titanium anodes forestall corrosion

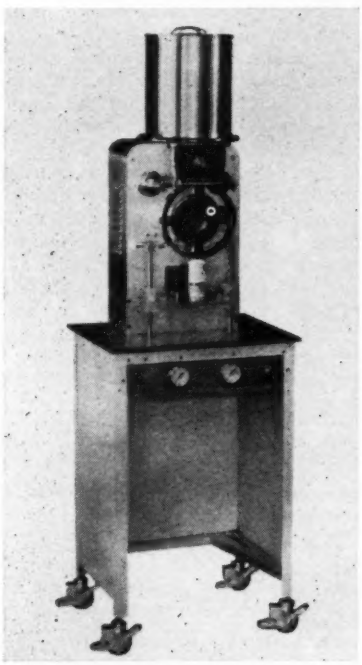
For impressed current cathodic protection of a variety of chemical and process plant and equipment, Cathodic Corrosion Control Ltd. are now offering anode rods of titanium with platinised areas for carrying the current, and a mounting unit to fit into steel or cast-iron walls. Electrical connections are made in a weatherproof box that is an integral part of the mounting. This box can be made flameproof by the use of flameproof glands and a suitable filling compound.

Should the unit have to be removed for inspection or maintenance, the junction-box cap fits into the hole left behind, thus eliminating the necessity for shut-down during maintenance. **CPE 1384**

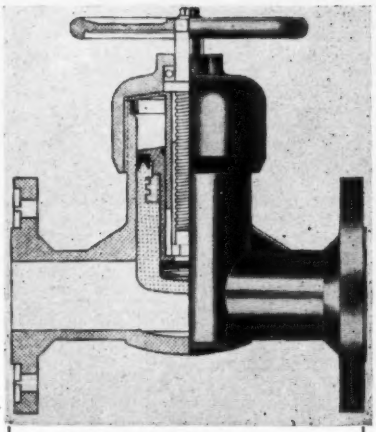
Powder filler

A powder filling machine designed especially for the aerosol trade is marketed by the Flexile Metal Co. Ltd.

The bulk hopper in which the powder is placed is positioned over a die wheel (filling head) which may be adjusted to fill containers ranging from 1½ to 12 in. in height and ¾ to 6 in. in diam. It is stated that round, square or oval containers can be filled with a high degree of accuracy and without dusting during the filling operation. Twin agitators in the hopper and hopper well keep the powder from caking or bridging while being fed to the die wheel. **CPE 1385**



Powder-filling machine.



TELESCOPIC VALVE

Telescopic plug valves are available in PVC, high-density polythene with a working pressure of 145 p.s.i. and for temperatures up to 140°C. The telescopic arrangement replaces the diaphragm, the valve being shut off through pressure applied to a soft-rubber cup. Manufactured in Germany, the valve is marketed in the U.K. by Goodburn Plastics Ltd. **CPE 1389**

Reynolds Number apparatus

A pre-packaged unit in which the Reynolds number experiment can be carried out in a quantitative way has been developed by Q.V.F. Ltd. The apparatus comprises essentially a vertically mounted glass tube, through the top of which water may be admitted at a controlled and measured rate. Two jets are fixed to the top of the tube, one at the centre and one near the wall, through which dye may be admitted to the water stream. Under laminar flow conditions the filament of dye from each jet proceeds separately down the tube. Onset of turbulence as water flow is increased is demonstrated by the break-up of the dye stream.

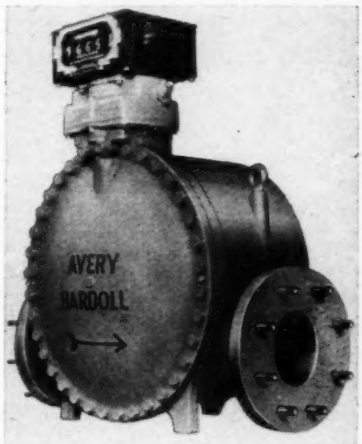
The flow of water to the apparatus is controlled by a valve and passed through a *Rotameter*. A thermometer is mounted in the head of the flow tube. Before entering the main tube the water flows through the jacket surrounding the tube and obviates disturbance in the main stream due to stray convection currents. A plastic scale on the side of the tube enables the rate of flow of the dye filaments to be measured under laminar flow conditions. **CPE 1386**

Fill in and post the reply-paid card for details of any items in these pages, making sure to quote the correct 'CPE' reference number.

Bulkmeter

Designed for high flow rates, including bunkering with heavy fuels, a bulkmeter by Avery-Hardoll Ltd. is equally suitable for light petroleum products, having a rated capacity of 1,500 gal./min. on fuel oil with a viscosity of 2,500 Redwood sec. 1 at 100°F.

The new meter will be fitted with a *Veeder-Root* reversing counter and has inlet and outlet in-line flanges of 8 in. internal diam. The approximate overall dimensions are: 36 in. high, 40 in. wide and 20 in. deep. The LBM 1000 is suitable for normal operating pressures up to 300 p.s.i. and is tested to 500 p.s.i. to withstand any surge pressures. **CPE 1387**



Bulkmeter fitted with reversing counter.

New valve

A useful valve in which lubrication is eliminated by the use of a PTFE-sleeved plug is described in a pamphlet from the Audley Engineering Co. Ltd., Newport, Shropshire. It is claimed that the use of this material eliminates the risk of galling and sticking due to metal-to-metal contact, while the valve is leakproof and has high resistance to chemical attack. **CPE 1388**

Atomic Energy in China

(*Concluded from page* 398)

year, a 4½-MeV. electron cyclotron was produced in Peking. Electron accelerators of other types were produced at the same time.

Uranium prospecting

China claims to be rich in uranium ore reserves. Specimens of different uranium ores and samples of uranium compounds and uranium metal were on show at last year's Peking exhibition, but so far no indication has been given of either the location or the size of the country's uranium reserves. There are believed to be important deposits in Sinkiang, the vast and remote mineral-rich north-western province where for some time the Soviet Union and China jointly operated petroleum and non-ferrous metals concerns. These undertakings have now come under Chinese ownership.

Prospecting for uranium (and in fact for all metals) is being carried out on a wide scale in China and in many areas peasants take part in the search for deposits. China is making universal, γ-β, pocket-size radiometers for use in detecting uranium and a light model radiometer for drill-hole logging. Particularly in remote areas, extensive use is being made of improvised equipment to prepare the ores.

During the past year numerous research institutes have been set up jointly by scientific institutes and universities or colleges. These institutes, which do not necessitate much in the way of either extra personnel or new equipment, have already made some important contributions to Chinese atomic research. Early this year, for instance, it was reported from Sian, in north-west China, that an electrostatic accelerator with a designed capacity of 500,000 v. had been made jointly by the Institute of Atomic Energy in the city and the department of physics of Chiaotung University.

Scientific education

China's progress in scientific and technical education in recent years has been impressive and here, obviously, is one of the keys to her scientific advances. The country's 1,400-odd colleges and universities (there were only about 230 as recently as 1957) now offer 323 fields of specialisation, including nuclear physics, radiochemistry, radio-electronics and automation. In the 1957-58 school year over 163,000 students were taking engineering courses—nearly six times the 1947 figure. Some 35,000 engineers graduated in the two years 1956 and 1957.

The Chinese University of Science and Technology, opened in the latter part of 1958 in the western suburbs of Peking, is intended to speed up nuclear advances in China. It is concentrating on teaching the newest branches of science, offering five-year courses in nuclear physics and nuclear engineering, radio electronics, geochemistry and rare elements, biophysics, automation, high-polymer chemistry, computing technique, dynamics, etc. Entrance to the university is on the basis of examinations held in the major cities of the country. Some 1,600 students have been enrolled at the university—about 600 more than the number originally planned. Teaching staff comes mainly from senior research workers of the Academy of Sciences.

Soviet aid

The Chinese freely admit that it is due to Soviet aid that they have been able to solve so many technical and scientific problems in such a short time and with such small resources of trained personnel. The 1954 Sino-Soviet Agreement on Scientific and Technical Co-operation marked the beginning of planned long-term co-operation between the two countries in this field. Last October the Chinese Government sent a scientific and technical mission to the Soviet Union and similar delegations were sent by the Chinese Academy of Sciences, the Academy of Agricultural Science and the Ministry of Higher Education. Atomic science figured prominently in the discussions with Soviet scientists. In December of last year the Chinese and Soviet Academies of Sciences concluded a detailed arrangement for co-operation and in January of this year an agreement was concluded between the governments of the two countries. This provides that during China's current five-year plan (1958-62) 122 important scientific and technical problems will be studied jointly by Chinese and Soviet scientists, or by Chinese scientists with Soviet aid.

Scientific and technical co-operation has also been increasing between China and the East European countries, both through the Scientific Council of the Joint Nuclear Research Institute* and by direct exchanges of personnel and data. East European as well as Soviet scientists played a part in working out China's 12-year plan for the development of science and technology. An East German government delegation visited China early this year and an agreement for scientific co-operation between the Chinese and East German Academies of Sciences was signed in March.

* The council consists of 32 physicists from the 12 member Communist countries (Soviet Union, China, Czechoslovakia, Poland, Hungary, Rumania, Bulgaria, Albania, East Germany, North Korea, North Viet Nam and Mongolia). A Chinese nuclear physicist, Prof. Wang Kan-chang, was elected a vice-director of the Institute at the 15th session of the council held in Dubna last January. Other vice-directors are V. Votruba (Czechoslovakia) and Prof. M. Danysz (Poland). The director is D. Blokhintsev (Soviet Union).

£ s d

CHEMICAL PLANT COSTS

Cost indices for the month of September 1959 are as follows:

Plant Construction Index: 178.7

Equipment Cost Index: 166.1

(June 1949 = 100)

£ s d

Of interest to our readers . . .

A number of articles appearing in our associate journals this month will appeal to readers of CHEMICAL & PROCESS ENGINEERING.

The Manufacturing Chemist makes a special feature of safety and an article on 'How to Prevent Accidents in a Fine Chemicals Factory' is sure to contain something useful for other sections of industry too. This is supported by a review of the latest safety equipment.

Petroleum reviews oil-refinery expansion in Europe and also has an article describing the new Whitegate refinery in Ireland, while the Ravenna petrochemical plant is also featured.

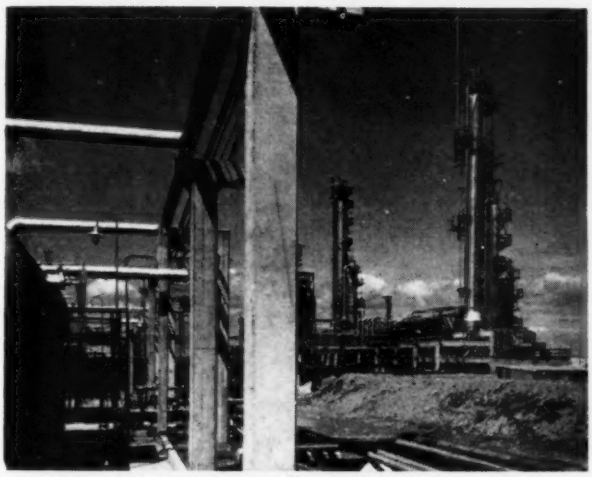
Corrosion Technology contains an article dealing with the permanent anode in impressed-current cathodic protection systems and another on electrical installations in corrosive environments.

Paint Manufacture. A contribution to this journal deals with the properties of *Rafaelite* — a naturally occurring asphaltum or asphaltite— and its applications in the manufacture of coatings, varnishes, inks and moulded products. The shapes and properties of polymer molecules are the subject of another interesting article.

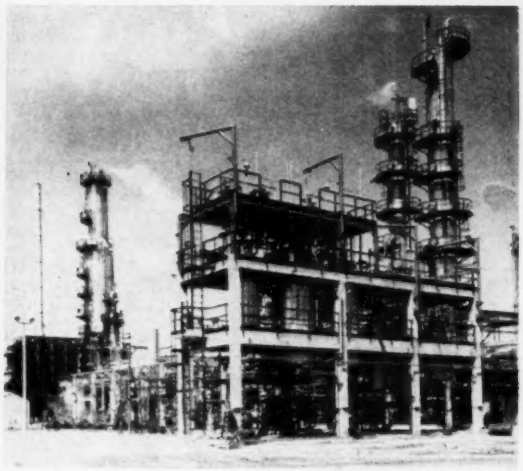
Specimen copies of these journals, and subscription forms, are obtainable from the Subscription Department, Leonard Hill House, Eden Street, London, N.W.1.

IRELAND'S FIRST OIL REFINERY

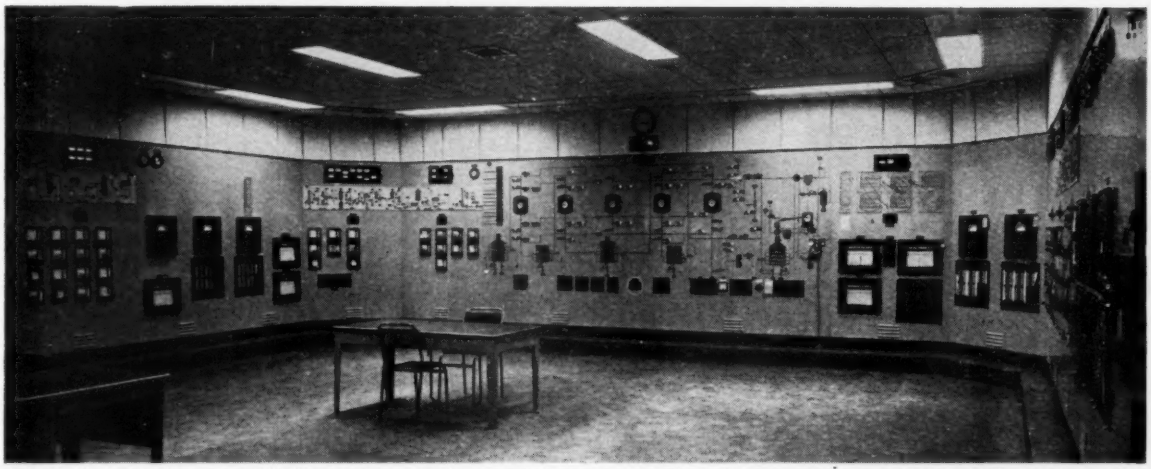
A PICTURE SURVEY OF THE ESSO PETROLEUM/SHELL MEX & BP/CALTEX REFINERY AT WHITEGATE



This photo shows (*on the right*) the ' Powerformer ' unit.

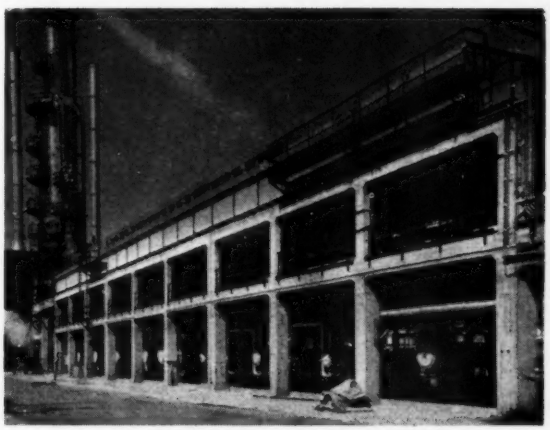


Copper chloride treating unit.



The main control room at Whitegate is centrally placed, the process units being grouped around the building. The panel carries some 100 ' Electroflo 361 ' pneumatic recorders, the majority being on the wings.

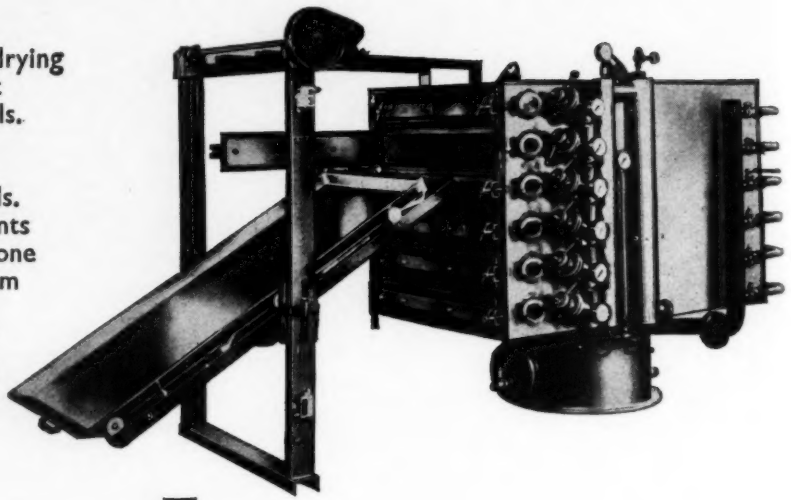
Compressor section of the ' Powerformer ' unit.



Air-cooled heat exchanger in the pipestill unit.

CALMIC C 51 VACUUM DRYER

For the rapid even safe drying of high moisture content materials. Pharmaceuticals. Antibiotics. Veterinary preparations. Dyes and pigments. Precious metals. Independent compartments —under vacuum within one minute of closing. Vacuum steam jacketed trays— rapid even heat transfer low temperature drying when required for heat-sensitive materials. One man operation.



HIGH DUTY PRESSURE FILTER— For clarification of liquids containing up to 7% solid matter. High output. Rapid operation. Cleanliness. Safety. Mobility.

C 3 VACUUM DRYER — Independent compartments as C 51 Dryer but without vacuum steam jacketed trays, Oil heated. Operates from ambient to 150°C. For granules, powders and all low moisture content materials.

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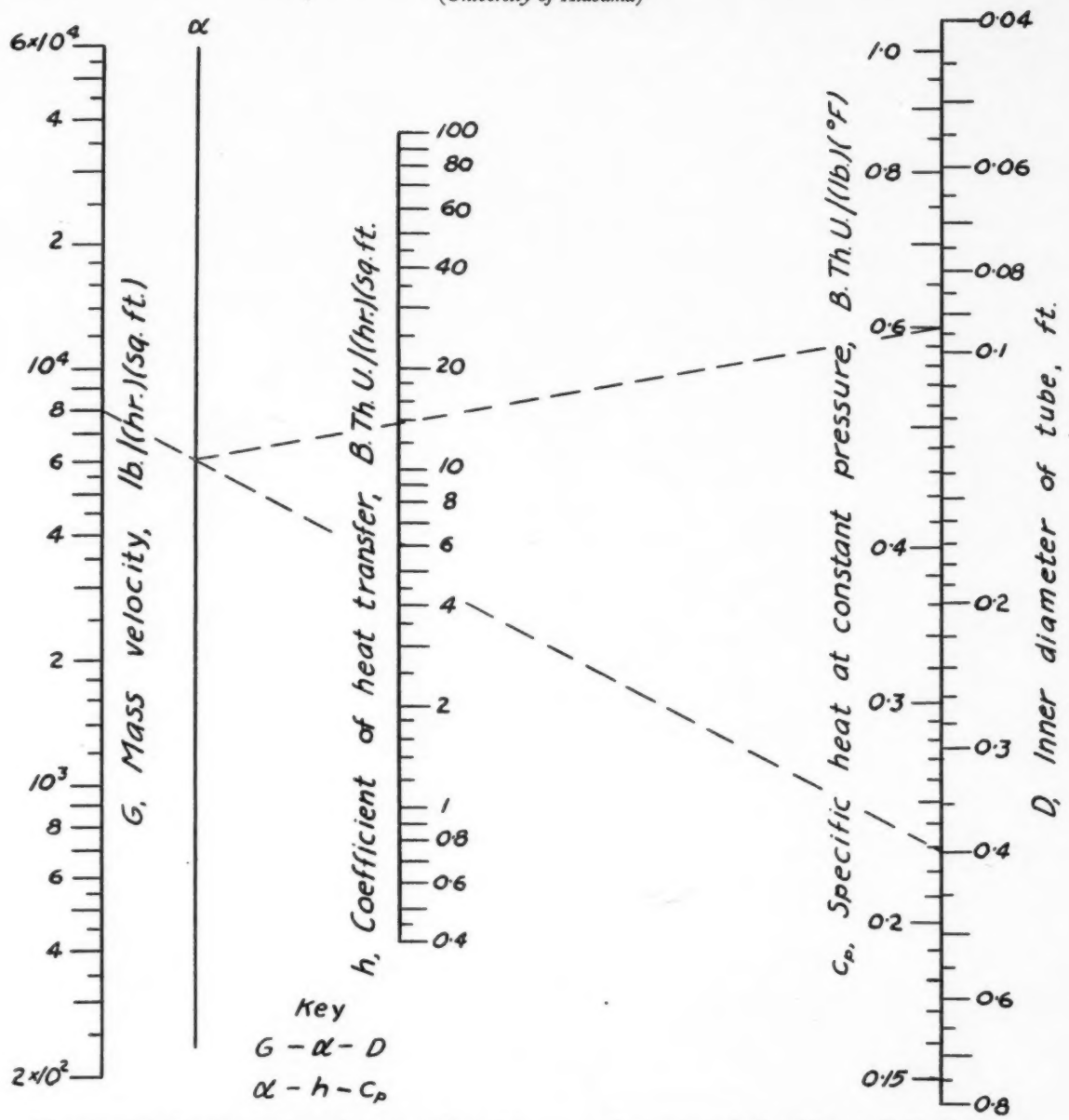
Heating and Cooling of Gases in Tubes

By D. S. Davis
(*University of Alabama*)


α
G, Mass velocity, lb./(hr.)(sq. ft.)
h, Coefficient of heat transfer, B.Th.U./(hr.)(sq.ft.
c_p, Specific heat at constant pressure, B.Th.U./(lb.)(°F)
D, Inner diameter of tube, ft.
Key
G - α - D
α - h - c_p

The accompanying nomogram replaces an earlier one[1] on which mass velocities were too low to ensure Reynolds numbers in the range of turbulent flow. The nomogram covers the heating and cooling of gases in tubes in accordance with an equation given by McAdams:[2]

$$h = 0.0144\ c_p\ G^{0.8}/D^{0.2}$$

where h = heat transfer coefficient, B.Th.U./(hr.)(sq.ft.)(°F.)

c_p = specific heat of gas at constant pressure, B.Th.U./(lb.)(°F.)

G = mass velocity of the gas, lb./(hr.)(sq.ft.)

D = inner diameter of the tube, ft.

The broken index lines on the chart show that the heat transfer coefficient is 13.9 B.Th.U.(hr.)(sq.ft.)(°F.) when the mass velocity is 8,000 lb./(hr.)(sq.ft.), the inner diameter of the tube is 0.4 ft., and the specific heat of the gas is 0.6 B.Th.U./(lb.)(°F.).

REFERENCES

[1]D. S. Davis, CHEMICAL & PROCESS ENGINEERING, 1959, **40** (5), 185.
[2]W. H. McAdams, 'Heat Transmission,' 3rd edition, p. 226. McGraw-Hill Book Co. Inc., New York, 1954.

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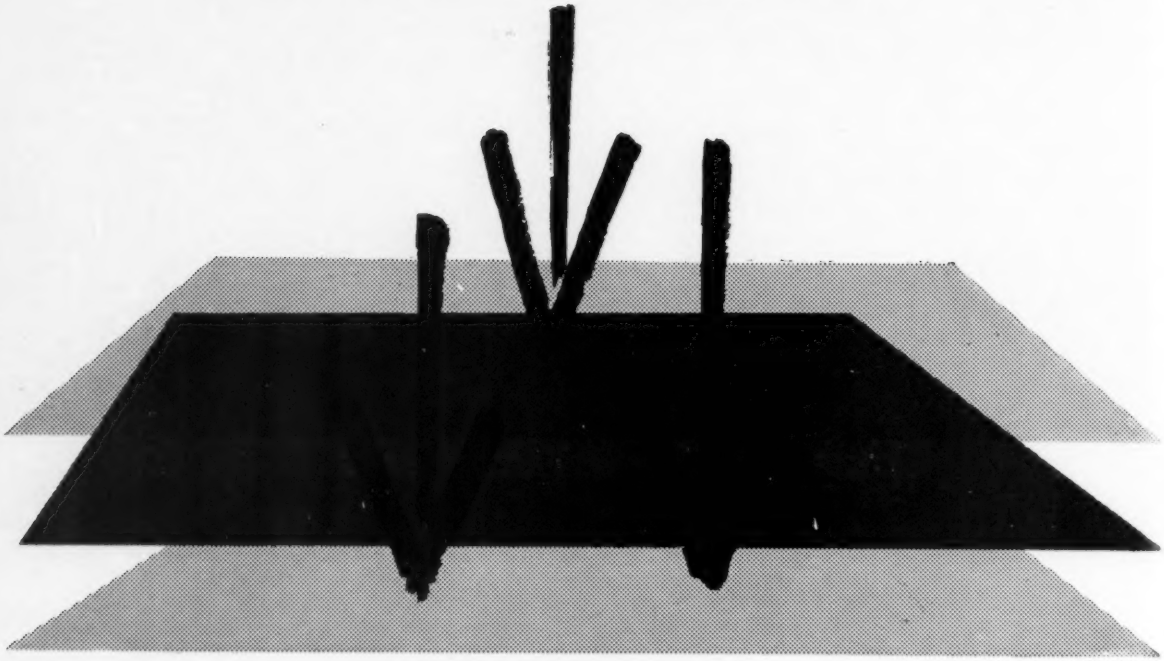

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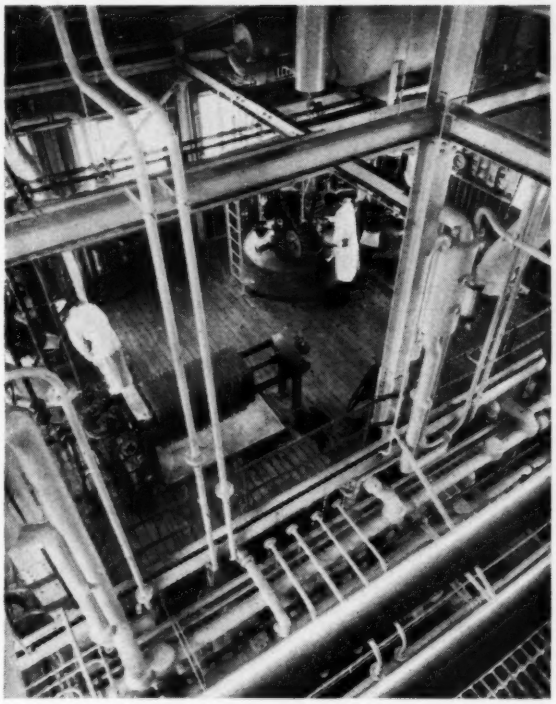
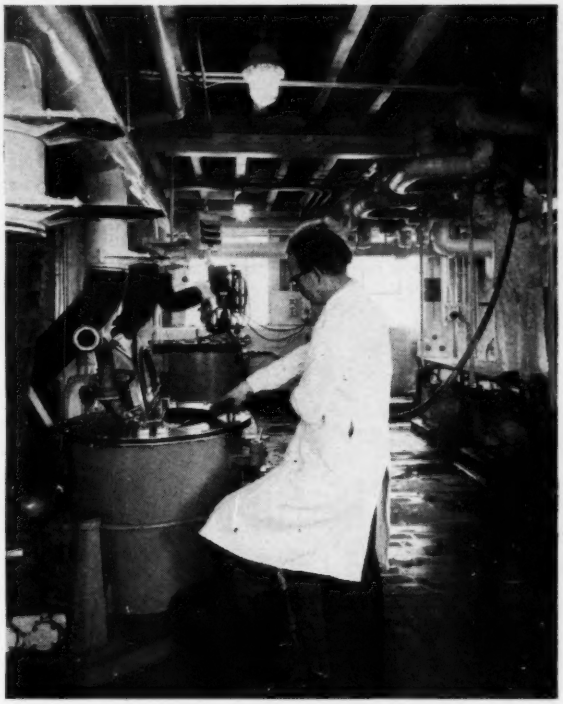
Pilot Plants for Antibiotics Manufacturers





Inside the new production-development building at Sandwich. *Left:* **Biochemical pilot plant, showing the filter used to extract mycelium from fermentation liquids.** *Right:* **Centrifuges in the organic synthesis pilot plant.**

PRODUCTION development facilities have now been added to the £2½-million terramycin factory, £1-million polio vaccine plant, ancillary chemical plants and research department of Pfizer Ltd. at Sandwich, Kent. The new facilities include a chemical development laboratory, an organic-synthesis pilot plant, a biochemical pilot plant and a fermentation development laboratory.

The pilot plant units are housed in a three-storey structure with the ground floor and first floor containing mainly organic synthesis equipment plus stainless-steel, glass-lined vessels for general purposes. The use of tetra aryl silicate in the heat-transfer system enables temperatures of –15 to 275°C. to be achieved—the expense of the system being justified by the remarkable flexibility of operation that can be obtained.

In this plant, the floors are of wood, which can be cu and drilled without introducing a fire hazard. Leak-proofing was achieved by caulking and sealing. A void in the centre of the plant houses the service lines and provides room for erecting fractionating columns, ion-exchange columns, etc.

The biochemical pilot plant is on the top floor and is equipped with stainless-steel vessels able to deal with volumes up to 500 gal. Fermentation products made in the 300-gal., stainless-steel tank are put through a stainless-steel filter to take out the mycelium. The filtrate then goes to a 500-gal., cone-bottom extractor with a cooling coil. Solvent extraction methods are employed and the product is finally isolated by concentration of the solvent phase, addition of coagulant, etc.

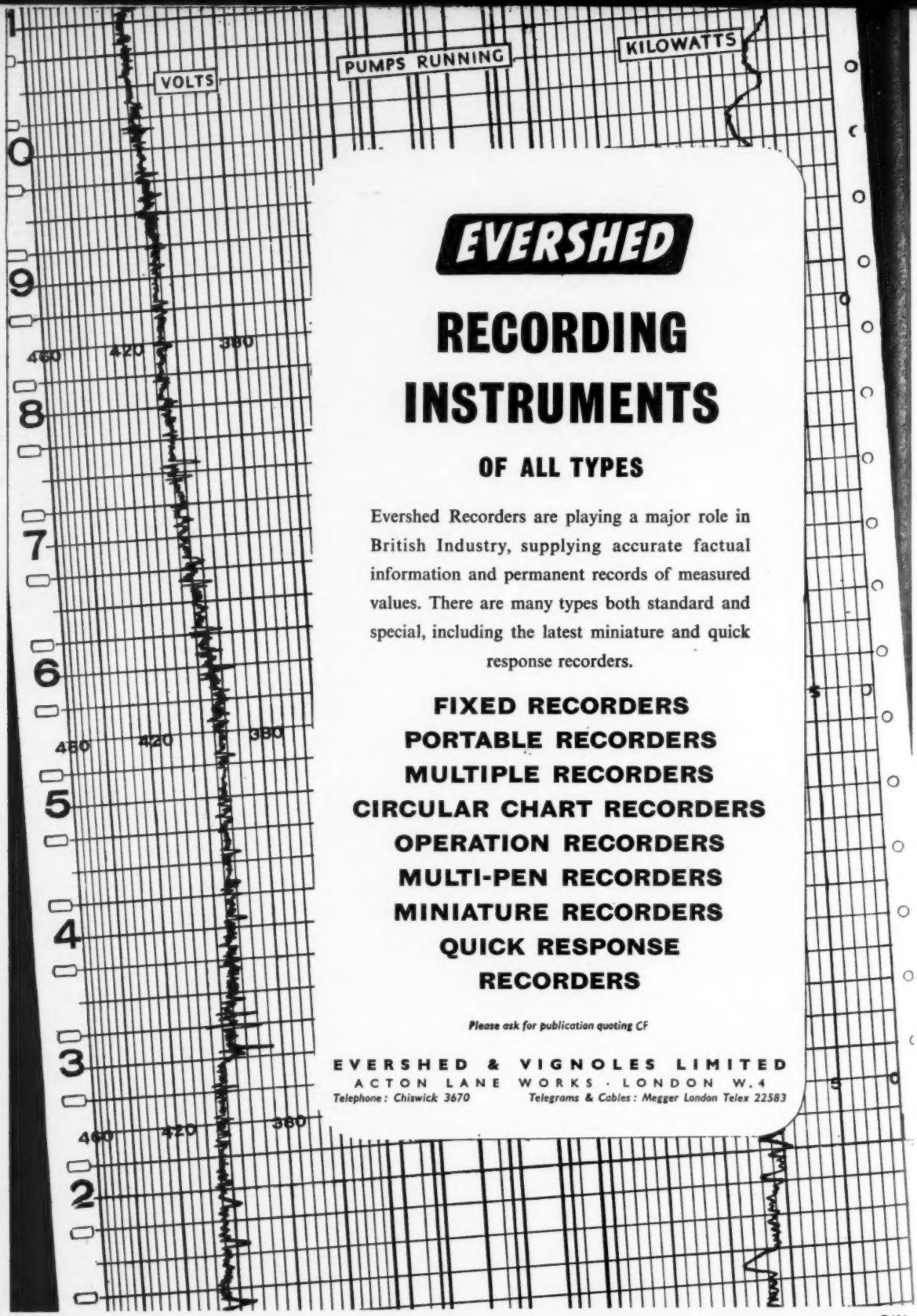
Industrial Publications

Mechanical seals. A catalogue (28 pages, illustrated) describes the *Flexibox* range of balanced and unbalanced mechanical gland seals for all types of rotary-shaft equipment — pumps, mixers, agitators, compressors, etc. Tables of essential dimensions, operating limits, power absorption and frictional heat development nomograms and details of PV ratings have been included. In addition a recommended materials specification for seal components is given for more than 350 fluids. Copies of the catalogue are obtainable from Flexibox Ltd., Nash Road, Trafford Park, Manchester 17.

Air relay. From Bailey Meters & Controls Ltd., Purley Way, Croydon, Surrey, comes a four-page product specification No. (E)P99-8 which describes and illustrates a pneumatic relay for use in automatic control schemes of all types where pneumatic control is preferred and where computing action is required. Specifications and typical applications are given and the principle of operation is explained.

Titanium. The first of a series of five booklets is entitled 'Wrought Products' and is of a general introductory nature, describing I.C.I.'s manufacturing facilities and production range, and indicating the principal outlets for titanium and titanium alloys. The 16-page illustrated booklet is obtainable from the company at Imperial Chemical House, Millbank, London, S.W.1.

Fluorescent lighting fittings are described in a four-page, illustrated pamphlet (L300/1) from Victor Products (Wallsend) Ltd., Wallsend-on-Tyne.



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World News

HUNGARY

Chemical industry to double production

Hungary's chemical industry must double its output by 1965 says a report issued in Budapest outlining the main aims of the country's second five-year plan (1961-65). Amongst other proposals is one that production of nitrogenous artificial fertiliser must be increased four or five times. Besides building the Tiszapalkonya artificial fertiliser factory, the annual capacity of which is 82,000 tons, the capacity of the nitrogenous artificial fertiliser plant of the Borsod chemical combine (Kazincbarcika) must be doubled.

Production of superphosphate, says the report, must rise from 200,000 tons (1958) to 650,000 tons (1965).

For industrial production generally, an increase of 65 to 70% is proposed.

SPAIN

Fertilisers

A nitrogenous fertiliser plant belonging to the Empresa Nacional 'Calvo Sotelo' has started operations at La Corunna. Initial production is to be 100,000 tons annually increasing to 200,000 tons within three years.

SWEDEN

Atomic power plans changed

The Swedish State Power Board has announced that its R4/*Eva* power plant project, originally scheduled to go into operation in 1965, has been postponed. Instead, the Board plans to take up discussions with A.K.K., a nuclear power development consortium, for building a joint smaller plant.

Under a new programme presented by Mr. E. Grafström, Director General of the Board, work will continue on the R3/*Adam* nuclear plant, principally designed for heat production and scheduled to become operative in 1963. Moreover, by the middle 1960s there should be completed—preferably in collaboration with A.K.K. — a 50-Mw. American-designed power reactor built under licence in Sweden. While the cost is reported to be approximately £8.6 million to £10.4 million, no details have been disclosed about the type of reactor to be used, but it is rumoured that the likely choice is a boiling reactor using enriched uranium of a type evolved by General Electric and Westinghouse. A.K.K. is reported to have already invited binding tenders from *Asea*, representing General Electric, and from the Johnson group of industries, representing Westinghouse.

The State Power Board says that it will continue its work on the 'Swedish line' in atomic development—based on the use of natural uranium as fuel and heavy water as moderator—with a view to having a full-scale power station completed by the end of the 1960s. Development work would be carried on in collaboration with the Swedish Atomic Energy Co. and with Swedish manufacturing industries.

AUSTRALIA

Copper refining

The first section of the new copper refinery erected by Copper Refineries Ltd., a subsidiary of Mount Isa Mines Ltd., at Stuart, Townsville, has been opened. It is already able to produce 40,000 tons of copper, value about £11 million, per annum. Construction has so far cost £3½ million, and another £1½ million will be spent to complete the project by 1961.

Plans are being laid for the expansion of the refinery to produce 100,000 tons of refined copper worth £30 million p.a.

Atomic energy agreement

An agreement for co-operation between Australia and Canada on the peaceful uses of atomic energy came into force on October 8. It is designed to facilitate exchange of information, equipment, material and fuel between the two countries, and enable them to use each other's facilities.

U.S.S.R.

Increased chemical output

According to the Central Statistical Board of the U.S.S.R. Council of Ministers, gross output of the chemical and rubber industries during the first nine months of 1959 was 110% of the corresponding period of 1958. Output of mineral fertilisers totalled 9½ million tons—103% of the corresponding 1958 period; sulphuric acid reached 3.7 million tons (106%) and artificial and synthetic fibres 131,000 tons (108%). Production of chemical equipment amounted to 1,200 million roubles (149%).

Dealing with individual sections of the chemical industry, it is revealed that the output of synthetic resins and plastics has increased by 14% (including alkyd resins, by 25%); cellulose ethers by 12%; polychlorvinyl resin and copolymers by 18%; synthetic ethyl spirits by 47% and synthetic fatty acids by 59%.

The plan for the output of chemical equipment has fallen somewhat short of fulfilment.

NETHERLANDS

Pharmaceutical factory

Considerable additions have been made to the factory, established at Haarlem in 1957, of Merck Sharp & Dohme Nederland N.V., a subsidiary of Merck & Co., U.S.A. The new plant will be used for the manufacture of a new product, *Chlorothiazide*, to be exported to European and Near Eastern countries. The extension required an investment of 3½ million guilders.

INDIA

Oil and natural gas

The Oil and Natural Gas Commission has become a statutory organisation, the Act providing for the establishment of this commission 'for development of petroleum resources and production and sale of petroleum and petroleum products produced by it and matters connected therewith' having been passed by the Indian Parliament recently.

Set up initially as a directorate under the (then) Ministry of Natural Resources and Scientific Research, the Commission was constituted in August 1956. Its main task has been to narrow the gap between demand for and production of oil and natural gas as much as possible by early assessment of the country's oil resources and discovery of new potential oilfields.

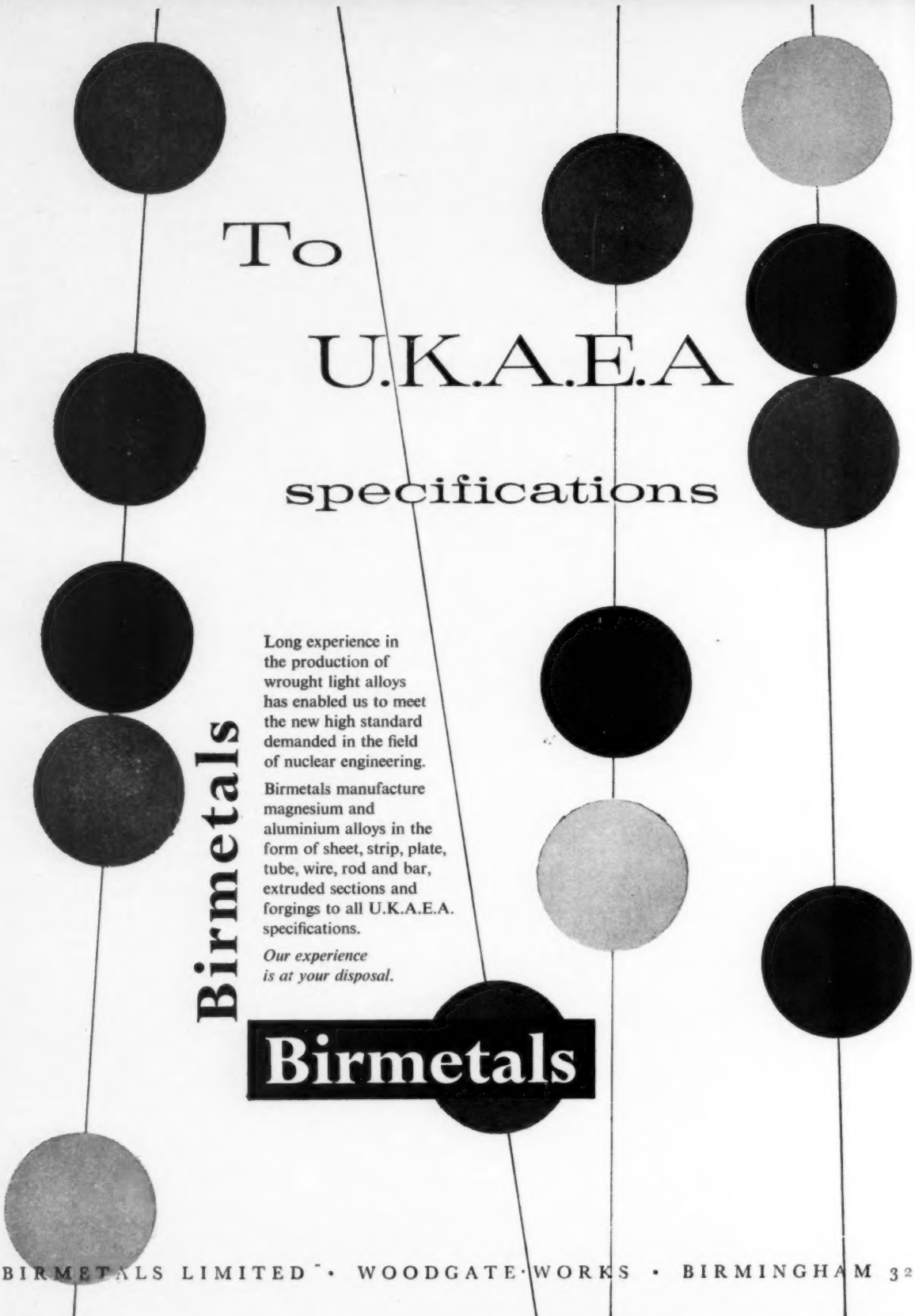
UNITED STATES

Nuclear reactor fuel reprocessing

Preliminary designs for a $6-million (£2-million) facility for reprocessing atomic power reactor fuel elements, at the Hanford Atomic Products Operation, have been started by General Electric (U.S.A.) who operate the plant for the U.S. Atomic Energy Commission. From 50 to 150 tons p.a. of highly diversified, low-enrichment spent fuel containing up to 5% Uranium-235 will be reprocessed, beginning early in 1961.

Uranium and plutonium will be separated from the spent fuel in *Redox* chemical separation plants by the solvent extraction process. Recovered uranium solutions will be made ready for re-use in the form of uranium oxide powder.

Spent fuels will also yield plutonium and waste fission products. Plutonium recovered will go into the Government supply.



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Company News

A large, horseshoe-shaped oil-refinery control panel, which will be 60 ft. long when complete, was inspected by 23 members of the Council of British Manufacturers of Petroleum Equipment when they paid a visit to the offices and works of Evershed & Vignoles Ltd. recently. The panel is designed to control two crude distillation plants, a *Hydrofiner*, a catalytic reformer, and a redistillation unit. This involves the provision of 120 separate control loops each embodying an Evershed mark IV controller, with associated transmitters and positioners as control elements. The visitors were also shown the servo motor department, coil winding room, and the process controller and amplifier department, where a demonstration model simulating plant conditions was operated. In the company's instrumentation test room the party saw a number of products of particular interest to the petroleum industries.

★

The whole of the issued share capital of the Infra-Red Development Co. Ltd. has been acquired by Hilger & Watts Ltd. I.R.D. was founded in 1946 and specialises in the analysis of gases by non-dispersive infra-red techniques, primarily for industrial purposes. Mr. W. B. Bartley, who has been responsible for the technical control and management of the firm, will remain managing director.

★

Rio Tinto and Dow Chemie A.G., which is the Swiss subsidiary of the Dow Chemical Co., have jointly acquired the share capital of Thorium Ltd. from Imperial Chemical Industries Ltd. and Howards & Sons Ltd.

Thorium Ltd., founded in 1914, processes crude thorium materials and has works at Widnes, Lancs. It produces refined thorium oxide and salts for the home market and for export. A substantial part of the company's business is connected with the production of cerium compounds and particularly cerium oxide optical polishing powders. A variety of rare-earth compounds is also produced.

Rio Tinto and Dow have been associated since the formation in 1958 of Rio Tinto Dow Ltd., a Canadian company which is producing crude thorium salts from the treatment of the barren liquors from uranium extraction at Rio Tinto's Algom Quirke mine in the Blind River area of Ontario.

The Rio Tinto Dow thorium plant, which came into production in May 1959, is the first of its kind in the world and uses a solvent extraction process.

★

The higher profits earned by the Chemical Division enabled the Fisons Group to establish a record net profit in 1958-59 in spite of a slight fall in turnover from the record achieved in 1957-58, according to the annual review of the chairman, Sir Clavering Fison. Chemical sales showed an increase of more than £1 million over the previous year.

In the fertiliser field, Fisons benefited from favourable trends in the cost of raw materials and this helped to make it possible for the company to reduce prices. The new nitrogen factory at Stanford-le-Hope (CHEMICAL & PROCESS ENGINEERING, July, page 247) makes possible increased manufacture of higher-grade compounds. In South Africa, a new £2-million fertiliser factory was brought into production in June this year.

Annual expenditure of the Fisons manufacturing companies on research, development and advisory services is being maintained at about £1 million, almost equally divided between the Chemical and Fertiliser Divisions.

Orders and Contracts

A $21-million contract has been signed between the Italian companies, Montecatini and Ansaldo, and the Neyveli Lignite Corporation Private Ltd., India, for the construction of the world's largest urea plant at Neyveli, about 140 miles from the city of Madras. Neyveli Lignite acted on behalf of the Indian Government in the negotiations for the plant which falls within the framework of India's second five-year plan for industrial development.

The installation will have a capacity of 500 tons/day and will employ the Fauser-Montecatini process for urea manufacture. It will operate on the 'total recycling system' and, it is claimed, will be the first plant in the world to transform all the ammonia exclusively into urea. Completion is planned for late 1962, with an anticipated on-stream date in early 1963.

A large lignite mine nearby will be equipped with an extraction unit to supply some 500,000 tons p.a. of raw material. The German firm of Pintsch Bamag, under a separate agreement, will supply units for drying and treatment of the lignite, its transformation into gas, and final purification. Another agreement, with Linde, will cover the installation for the fractional distillation of the air and gas for the gas synthesis mixture. Some 300 tons/day of anhydrous ammonia will be manufactured, using the Montecatini process.

★

Orders for five Wiggins' dry-seal gasholders, to be supplied to India, have recently been received by member companies within the Power-Gas Group. P.G. Engineering Ltd. are to supply one of the holders, of 1,500 cu. ft. capacity, to an order by a United Kingdom firm. The other four are part of a contract received by the Power-Gas Corporation Ltd., Bombay, for the Indian Atomic Energy Establishment. These four holders are being manufactured in India, special items only being supplied from the United Kingdom.

Chemical Construction (G.B.) Ltd. have been awarded a contract by N.V. Maatschappij Tot Exploitatie Van Kooksovengassen (*Mekog*) of Ijmuiden, Holland, for a gas reform plant to treat natural gas for the production of ammonia synthesis gas.

The plant will reform approximately 125,000 cu.m./day of natural gas and is followed by a CO conversion plant producing a gas suitable for sending to the existing purification and ammonia synthesis plant.

★

Head Wrightson Iron & Steel Works Engineering Ltd., a subsidiary of Head Wrightson & Co. Ltd., have received an order from Colvilles Ltd. for the supply and construction of a blast-furnace-gas-cleaning plant at Ravenscraig in Scotland. The plant will mostly be manufactured by Head Wrightson at their works on Teeside.

This is an extension to a similar plant constructed by Head Wrightson two years ago at Ravenscraig and forms part of Colvilles' extensive strip mill project. The complete plant will be capable of cleaning 15 million cu.ft./hr. of blast-furnace gas and new equipment now to be supplied will

comprise a gas washing tower and two Cottrell wet-tube electrostatic precipitators together with the necessary gas mains, valves, pumps, water mains, etc. Ancillary equipment will also be supplied for the handling and recovery of sludge from the circulating water system.

It is expected that the plant will be in commission by the middle of 1961. The value of this contract is approximately £357,000.

★

Plant involving the recently developed *Frodingham Desulphurising Process* has been ordered from Henry Balfour & Co. Ltd. by the East Midlands Gas Board and the South Western Gas Board.

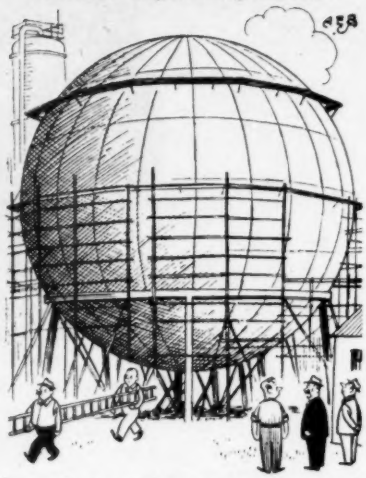
At Basford gasworks, Nottingham, a unit with a capacity of 5 million cu.ft./day of gas is to be installed for the simultaneous removal of H_2S and organic sulphur. This is a semi-experimental plant and is not yet provided with facilities for the recovery of the sulphur as sulphuric acid.

At Exeter gasworks a complete plant with a capacity of about 8 million cu.ft./day of gas is to be installed, together with a sulphuric acid plant of the dry contact type, the acid plant being supplied by the Power-Gas Corporation. The Exeter plant is designed for 99% removal of H_2S with the simultaneous removal of organic sulphur compounds to the extent of 90%, with the exception of thiophen, which is expected to be reduced by about 20%. The sulphur thus removed is recovered as sulphuric acid of high purity and of 98% strength.

★

G.W.B. Furnaces Ltd. announce that they will be supplying what is probably the largest packaged boiler plant to be installed in Great Britain. The installation, for the new factory of Henry Wiggin & Co. at Hereford, will consist of five *Powermaster* packaged automatic oil-fired boilers, capable of producing from 4,000 to 104,000 lb./hr. of steam at efficiencies of over 80%. Using oil of 3,500 sec. Redwood No. 1 or C.T.F. 200, the *Powermasters* will be used to provide space and process heating. Installation of the boilers will commence early next year.

Comical Engineering Corner



'GEORGE? – YOU SAY GEORGE WAS WORKING INSIDE?

Personal Paragraphs

★ **Mr. M. J. S. Clapham** has been appointed chairman of I.C.I. Metals Division from January 1, 1960, in succession to **Dr. M. Cook,** C.B.E., who retires from the company's service on December 31. Mr. Clapham has been joint managing director of I.C.I. Metals Division since October 1952. He is a director of Pyrotenax Ltd., Yorkshire Imperial Metals Ltd. and Imperial Aluminium Co. Ltd. He is chairman of the Non-Ferrous Wrought Metals Export Group and a vice-president of the British Non-Ferrous Metals Federation. Dr. Cook, who has earned great distinction in research and development work on metals, is a director of Yorkshire Imperial Metals Ltd. He joined the research department of Kynoch Ltd. in 1926. He was appointed research manager of the Metals Group of I.C.I. in 1938, and director in charge of research and development, Metals Division, in 1942. He became joint managing director in 1951 and chairman in 1957.

★ **Mr. J. W. Ashley,** chief engineer of Atomic Power Constructions Ltd. since the company's inception, has been elected to the board as technical director. He heads the team responsible for the design and construction of the 500 Mw. nuclear power station now being built for the Central Electricity Board at Trawsfynydd, North Wales.

★ **Mr. B. D. Baines,** senior applications engineer, has been appointed technical sales manager of the Hawker Siddeley Nuclear Power Co. Ltd.

★ **Mr. J. Harrison** has been appointed managing director of Atlas Copco (Great Britain) Ltd. in place of **Mr. J. C. Greig,** who has resigned. Mr. Harrison has been with the Atlas Copco international group of companies for six years and became deputy managing director of Atlas Copco (Great Britain) Ltd. in June 1959.

★ **Dr. E. Pohland,** of the German Bundesministerium fur Atomkernenergie (German Federal Ministry for Atomic Energy), has been appointed general manager of the European Company for the Chemical Processing of Irradiated Fuels ('Eurochemic').

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He was elected chairman of the board last July. **Dr. R. Rometsch,** formerly of the Swiss Ciba concern, has been appointed research director of 'Eurochemic.'

★ **Mr. F. Burgess** (Whites-Nunan Ltd.) has been elected chairman of the British Valve Manufacturers' Association for the year 1959-60. **Mr. J. W. Plowman** (Dewrance & Co. Ltd.) has been elected vice-chairman. Mr. Plowman is immediate past-chairman of the Association.

★ **Dr. H. R. Ambler** has been appointed to the newly created post of Scientific Adviser to the U.K. High Commissioner in New Delhi, India. He is at present Assistant Director of the Ministry of Supply's Chemical Inspectorate at Woolwich.

M. J. S. Clapham.